MECHANICAL ENGINEERING

· JUNE 1948 ·

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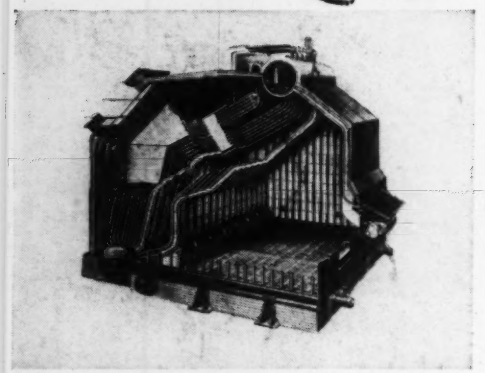

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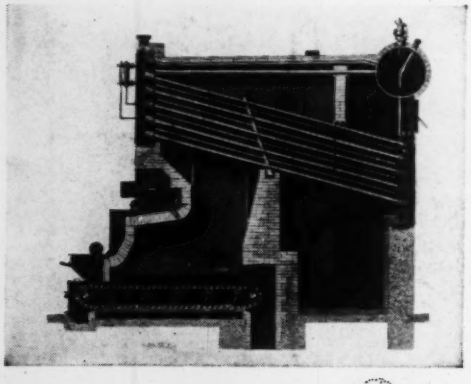

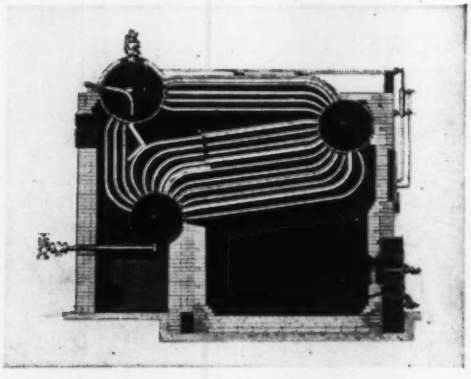

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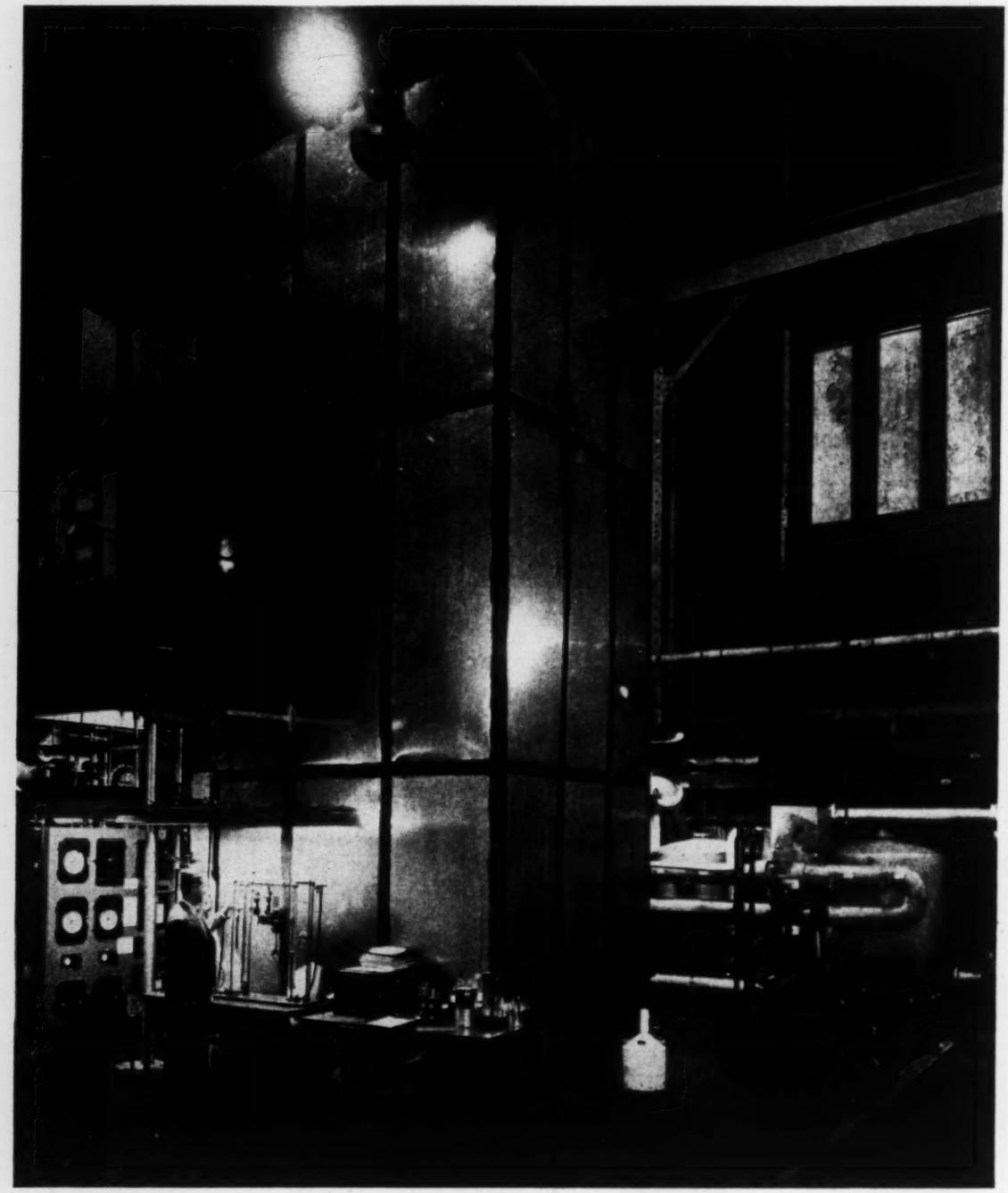

Oxygen-Generating Pilot Plant

(This plant in the Elliott Company's Jeannette, Pa., Works represents more than two and a half years of development, involving the use of new materials and equipments, many of which have to operate under exceedingly low temperatures. *See page 535 of this issue.)*

MECHANICAL ENGINEERING

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No. 6

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1948

GEORGE A. STETSON, *Editor*

How to Find It

THE task of making papers presented at meetings of The American Society of Mechanical Engineers available to members and to the public is not as simple as it was when meetings were few and the number of papers small. In the early days of the ASME the publications, particularly the Transactions, served this purpose admirably. But today conditions are different. Engineering societies have grown in size and complexity. The varied interests of their members have led to the organization of numerous groups within the fields of major interest, many of which are as large as the whole society was at the turn of the century. A single publication has been replaced by several, each with its own subscription list. And at technical sessions more papers are presented and discussed than can be accommodated in the publications.

It would seem at first glance as though the task of finding an ASME paper were growing continuously more difficult and yet, when the procedures are understood, it must be admitted that it is not as difficult as it seems to be. Hence a review of these procedures should be helpful to engineers who are not familiar with them.

In preparation for ASME meetings, technical papers are turned over to the editorial staff just as soon as they have been reviewed and recommended for presentation and publication. Decision is then taken by the Publications Committee in respect to preprinting. Papers destined for Transactions, *Journal of Applied Mechanics*, and MECHANICAL ENGINEERING are put in type form if they are received before the 90-day dead line. Papers received after this dead line, but still in time for processing by other means, are mimeographed. As each paper reaches the editorial department it receives a preprint number and this number appears in the preliminary program, in any circulars advertising the meeting, and in the final program. As preprints become available they are condensed and the resulting digests are published as soon as possible in the "ASME Technical Digest" section of MECHANICAL ENGINEERING. As soon as preprint numbers are made public in the preliminary programs or in MECHANICAL ENGINEERING, copies of the preprints may be purchased of the ASME Publication-Sales Department.

Papers received too late for preprinting are handled in much the same manner. Papers of high quality and general interest are published in MECHANICAL ENGINEERING in full or condensed form. If a late paper is destined for Transactions or *Journal of Applied Mechanics*, a digest of it appears in MECHANICAL ENGINEERING about the time it is ready for publication in these other periodicals. Thus MECHANICAL ENGINEERING eventually publishes, in full or condensed or digest form, every paper for which a manuscript has been made available. References to these papers and digests can be found in the indexes of MECHANICAL ENGINEERING, Transactions, or the *Journal of Applied Mechanics*, as the case may be.

Under the present ASME publication plan a member may purchase an individual copy of every paper for which a digest has been published in MECHANICAL ENGINEERING. Individual copies of MECHANICAL ENGINEERING papers are available only when the paper has been received in time for preprinting, but as every member receives that magazine he sooner or later has an opportunity to read all of these papers without ordering separate copies. If he also subscribes to Transactions or the *Journal of Applied Mechanics*, he eventually sees all papers published in those periodicals. The digests tell him if full publication is contemplated.

All ASME publications and preprints of papers are sent to the Engineering Index, Inc., and the Engineering Societies Library, both housed in the Engineering Societies Building in New York. The Engineering Index prepares an annotated index card of every ASME paper and distributes these cards to its subscribers. One set of these cards is on file in the Engineering Societies Library and there are many other libraries on the subscription list. When a preprinted paper appears in published form in ASME publications or in other magazines, other cards are prepared, and at the end of the year, when a bound volume of all Engineering Index references is published, all references to any one paper are combined. Thus a user of the Index is led to various publications where the paper may be found and a permanent record of availability is made.

The Engineering Societies Library catalogs every ASME preprint and retains a copy (some, unfortunately, are stolen) until the paper is published. The Library maintains a photostat service and hence is able to provide photostat copies of these papers, either from the preprint if the paper is never published, or from ASME publications if it is, for years after the date of the meeting and long after all ASME copies may have been sold out.

Thus through the Engineering Index and the Engineering Societies Library engineers should be able to find any ASME paper and get at least a photostat copy of it if he cannot buy a preprint copy. Bound volumes of ASME publications are easily accessible to him even if he does not subscribe to them or keep them in his own library because ASME maintains free depositories in

about 245 libraries scattered throughout the United States, and others in other cities throughout the rest of the world. For example, wherever there is an ASME Student Branch there is an ASME Transactions depository. In addition to these free official depositories there are many other libraries which subscribe to ASME publications and maintain files of bound volumes.

To summarize: The engineer's first access to ASME papers is in the purchase of preprints announced in preliminary and final programs of meetings. If he utilizes the "ASME Technical Digest" section of MECHANICAL ENGINEERING and keeps in touch with the text pages month by month, he can read every paper in digest, condensed, or complete form and he is told if the paper is to appear in Transactions or *Journal of Applied Mechanics*. He can subscribe to Transactions and the *Journal of Applied Mechanics* at low rates, or he can find copies in the Engineering Societies Library and in 245 ASME depository libraries, probably also in his own city library and possibly in his company library. He will find complete index references in MECHANICAL ENGINEERING, Transactions, or the *Journal of Applied Mechanics*. In the Engineering Index he will find references not only to ASME sources but to other magazines which reprint ASME papers. If all other sources fail, he can get photostat copies of ASME papers, even if they have appeared in mimeograph form only, through the Engineering Societies Library at usual rates. Other large libraries may offer similar services, but in so far as it is humanly possible to do so, the Engineering Societies Library can supply his needs.

It should be apparent, therefore, that there are direct and accessible means of finding ASME papers, past and current, and of getting copies of them, even though the number of technical publications increases and the number of technical papers makes it necessary to issue some of them in mimeograph or condensed form. Watch MECHANICAL ENGINEERING for current papers and use the Engineering Index and ASME publications indexes for older papers. Copies of current papers can be purchased or found in the ASME publications. The libraries, and particularly the Engineering Societies Library, should be consulted for copies of out-of-print papers.

The Scientist Speaks

WHEN the Lord answered Job out of the whirlwind and threw down the challenge to his understanding and taught the lessons of repentance and humility, science was not what it is today. Even the method by which men have progressed in science was unknown, although the universal yearning for explanations troubled men as it does today. We may, metaphorically, have "loosed the bands of Orion" by splitting the atom, but in spite of science, Job's plaint, "Man is born unto trouble as the sparks fly upward," seems quite as valid to many of us as it did to him. Yet we still hope that science may improve us and our lot and we look to men of science for our salvation.

How one scientist views the relation of science to society is to be found in an address, "Physics in the Contemporary World," by J. Robert Oppenheimer, at the Massachusetts Institute of Technology last November. "No scientist," he declared, "can hope to evaluate what his studies, his researches, his experiments may in the end produce for his fellow men, except in one respect—if they are sound they will produce knowledge."

The address is worthy of thoughtful study and of many readings, for it is the scientist himself who speaks, not someone speaking for him. "In this field," he says, "quite ordinary men, using what are in the last analysis only the tools which are available in our society, manage to unfold for themselves and all others who wish to learn, the rich story of one aspect of the physical world, and of man's experience. We learn to throw away those instruments of action and those modes of description which are not appropriate to the reality we are trying to discern, and in this most painful discipline, find ourselves modest before the world. The question which is so much in our mind is whether a comparable experience, a comparable discipline, a comparable community of interest, can in any way be available to mankind at large."

Speaking of the relationship between science and technology, Dr. Oppenheimer said: "The great testimony of history shows how often in fact the development of science has emerged in response to technological, and even economic needs, and how in the economy of social effort, science . . . . . pays for itself again and again in providing the basis for radically new technological developments . . . . The debt of science to technology is just as great. Even the most abstract researches owe their very existence to things that have taken place quite outside of science, and with the primary purpose of altering and improving the conditions of man's life. As long as there is a healthy physics, this mutual fructification will surely continue."

Toward the end of the address this paragraph is found. "In the first instance, the work of science is cooperative, a scientist takes his colleagues as judges, competitors, and collaborators. That does not mean, of course, that he loves his colleagues; but it gives him a way of living with them which would be not without its use in the contemporary world. The work of science is disciplined, in that its essential inventiveness is most of all dedicated to means for promptly revealing error. One may think of the rigors of mathematics, and the virtuosity of physical experiment as two examples. Science is disciplined in its rejection of questions that cannot be answered, and in its grinding pursuit of methods for answering all that it can. Science is always limited, and is in a profound sense unmetaphysical, in that it necessarily bases itself upon the broad ground of common human experience, tries to refine it within narrow areas where progress seems possible and exploration fruitful. Science is novelty, and change. When it closes it dies. . . . These qualities constitute a way of life which of course does not make wise men from foolish, or good men from wicked, but which has its beauty and which seems singularly suited to man's estate on earth."

ENGINEERING *for* ALUMINUM-ALLOY CASTINGS

By T. R. GAUTHIER[1] AND H J. ROWE[2]

ALUMINUM COMPANY OF AMERICA, PITTSBURGH, PA.

INTRODUCTION

ENGINEERING has been defined as the art and science of using the mechanical properties of matter in structures and machines. The field of mechanical and design engineering covers the selection of such matter for the construction and adaptation of machinery. The selection of a structural or engineering material for any application is determined by two basic requisites; the suitability of the material and its method of fabrication, and its cost in the form required. The engineer may find several engineering materials suitable for an application, in which case the selection of a material is governed primarily by economics. In other instances, one material may be definitely more suitable because of its superior engineering properties or characteristics. In this case, the functional requirements of the structure govern the selection, although the ultimate cost must be carefully balanced against the other necessary engineering properties.

The manner in which the selected engineering material can be fabricated to fit an application is one of the first considerations requiring the decision of the engineer. Aluminum alloys, because they are capable of fabrication by all commercial methods, provide a variety of possibilities from which to make this choice. Among these are castings produced by several processes, including sand castings, permanent and semipermanent mold castings, die castings, and castings produced in other nonmetallic refractory-type molds. The fabrication of aluminum alloys by the casting processes has been found to fulfill the two basic requisites of an engineering material for many structures.

Broadly, the properties and characteristics of aluminum-alloy castings are determined by three factors, i.e., (1) the alloy composition and its heat-treatment, if any; (2) the basic design features; and (3) the casting process by which they are fabricated. Some of the components of these three factors which require consideration by a design engineer are outlined.

ALUMINUM ALLOYS AND SOME OF THEIR CHARACTERISTICS

Of first importance to an engineer considering aluminum castings are the physical and mechanical properties of the particular aluminum alloy. When he finds the combination of properties desired, he then must consider some of its other characteristics such as machinability, resistance to corrosion, weldability, and, perhaps most important, its casting qualities and adaptability to the specific casting in question and the casting process involved.

Pure aluminum possesses neither mechanical properties nor casting characteristics suitable for general casting use. However, by the addition of other elements in controlled amounts, both of these characteristics can be greatly improved. In addition, heat-treatment processes will increase further the mechanical properties of many of these materials, as well as provide dimensional stability where this characteristic is required. Today there exist a large number of alloys which possess the required characteristics for casting work and provide a wide range of engineering properties. Tables 1 and 2 list the nominal composition and some of the mechanical properties of the most commonly used aluminum casting alloys as included in the specifications of the American Society for Testing Materials (ASTM).

Aluminum alloys in which copper is the principal hardening constituent were widely used in the early history of the aluminum-casting industry in this country. Such alloys containing about 8 per cent copper were used in the as-cast condition, depending upon the alloying addition only for their mechanical properties. Later the 4 per cent copper alloys were developed for sand and permanent-mold use. These alloys provided the design engineer with an improved material because they responded to heat-treatments thus developing a superior combination of ductility and strength over the earlier as-cast 8 per cent aluminum-copper alloys.

Although both the aforementioned types of alloys still find use today, they have been substantially replaced by alloys containing silicon as a major alloying element. This trend reflects the better casting characteristics provided by silicon additions and the recognition by designers of the superior mechanical properties of castings as a whole, resulting from the improved casting soundness. Casting production today in the majority of foundries is predominantly in the silicon-containing alloys, and it is expected that their use will continue to expand as designers recognize their superior qualities.

In this latter class are the straight aluminum-silicon alloys, the most important being the 5 per cent silicon alloys. Additions of copper to the aluminum-silicon alloys provide several variations with improved hardness and machining properties. Such alloys are usually supplied in the as-cast condition depending on the alloying additions only for their properties. By the addition of magnesium to this class of alloy, alloys capable of improved mechanical properties on heat-treatment are produced. It is such alloys that today provide the most desirable combination of casting characteristics and mechanical properties for general engineering applications. Intricate castings with thick and thin sections, requiring freedom from leaks, are more readily cast in these alloys than in the aluminum-copper-type alloys.

A number of aluminum alloys developed for more or less special purposes are also available in castings. In this class are the aluminum-magnesium alloys providing superior resistance to corrosion and tarnish. A heat-treated 10 per cent magnesium alloy offers the highest mechanical properties available in any of the aluminum alloys, although it possesses some foundry limitations. Where properties at elevated temperatures are required, a 10 per cent copper-magnesium or a 4

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[2] Chief Metallurgist, Central Metallurgical Department, Castings Division.

Contributed by the Metals Engineering Division and presented at the Annual Meeting, Atlantic City, N. J., December 1–5, 1947, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

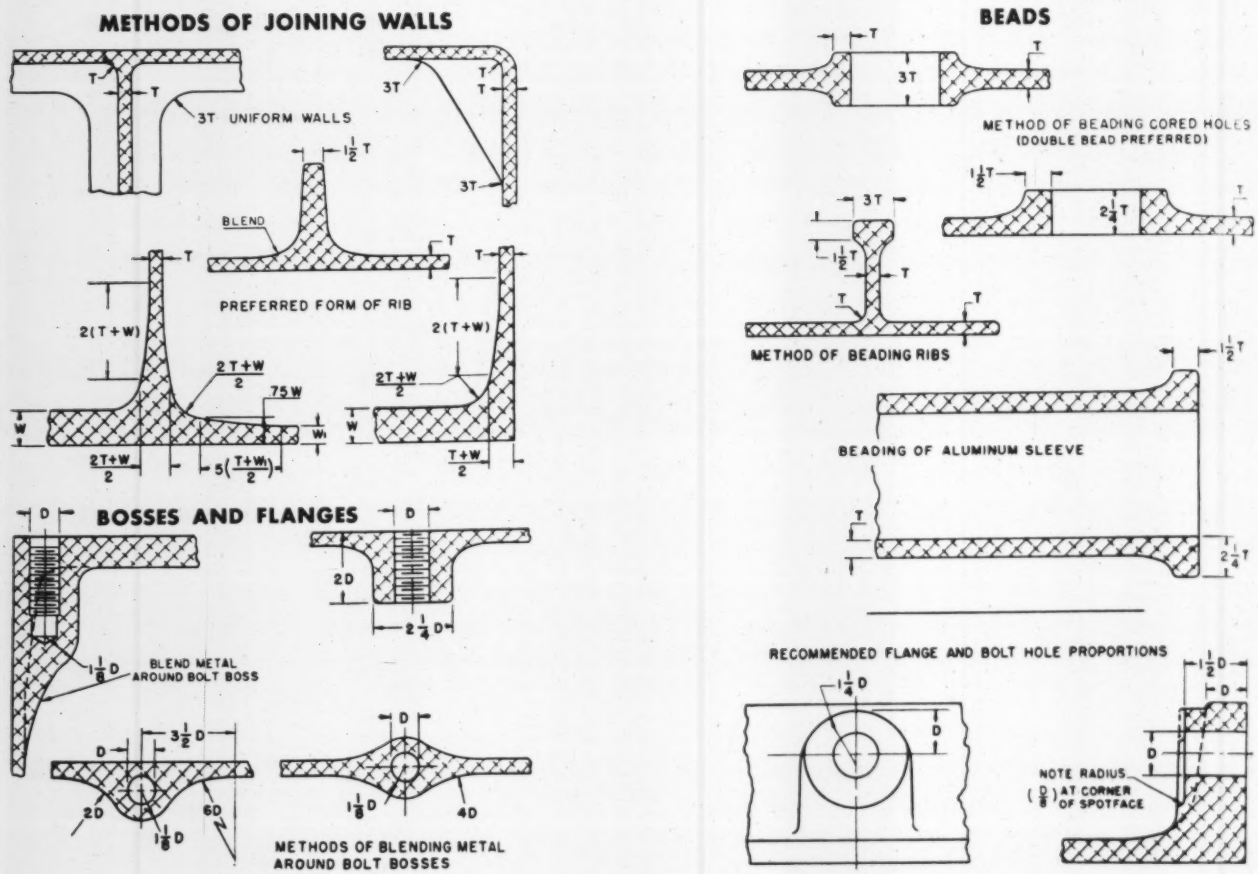
METHODS OF JOINING WALLS
3T UNIFORM WALLS
BLEND
PREFERRED FORM OF RIB
BOSSES AND FLANGES
BLEND METAL AROUND BOLT BOSS
METHODS OF BLENDING METAL AROUND BOLT BOSSES
BEADS
METHOD OF BEADING CORED HOLES (DOUBLE BEAD PREFERRED)
METHOD OF BEADING RIBS
BEADING OF ALUMINUM SLEEVE
RECOMMENDED FLANGE AND BOLT HOLE PROPORTIONS
NOTE RADIUS (D/8) AT CORNER OF SPOTFACE

FIG. 1 SOME SUGGESTED DESIGN DETAILS FOR ALUMINUM-ALLOY CASTINGS

per cent copper-nickel-magnesium alloy is available. Specific electrical and chemical requirements are provided by still other alloys.

Unfortunately no one alloy possesses, to the highest degree, all of the properties which may be desired by a designer. Also, all alloys are not equally suited to all methods of casting. Hence the selection of an alloy for any particular application requires the careful weighing of the characteristics offered against the characteristics desired, and the establishment of a suitable compromise. The casting producer's experience can be very helpful in making this selection and should be used whenever possible. Certain general considerations with respect to the design of the casting will also minimize some of the alloy limitations.

CASTING DESIGN CONSIDERATIONS

In establishing a casting design, the process by which the part is to be cast will influence many functional design features. Among the design factors which must be considered in selecting the casting process are the uniformity of section thickness, intricacy of the shapes and cores, dimensional tolerances desired, and the surface finish required. The number of parts required and the amount of subsequent machining and finishing are also factors affecting both design and economics which must be considered. Some of the fundamental design features applicable to all the casting processes are discussed here, and specific features of design as they affect the various casting processes will be reviewed in the discussion of the individual process.

The design engineer, by following a few general rules, not

TABLE 1 NOMINAL COMPOSITION OF COMMONLY USED ALUMINUM CASTING ALLOYS[a]

Commercial designation	ASTM designation	Nominal Alcoa composition, per cent Cu	Si	Mg	Zn	Ni
13	S5	...	12.00	...	..	....
40E[b]	ZG41	Cr	0.50	0.55	5.50	Ti 0.2
43	S1	...	5.00	...	..	....
85	SC2	4.00	5.00	...	..	....
108	CS5	4.00	3.00	...	..	....
A108	SC1	4.50	5.50	...	..	....
113	CS22	7.00	2.00	...	1.70	....
122	CG1	10.00	...	0.20	..	....
A132	SN41	0.80	12.00	1.20	..	2.50
138	CS21	10.00	4.00	0.30	...	....
142	CN21	4.00	...	1.50	..	2.00
152	CS23	7.00	5.50	0.30	..	....
195	C1	4.50	0.80	...	..	....
B195	CS4	4.50	2.50	...	..	....
214	G1	...	...	3.80	..	....
A214	GZ1	...	...	3.80	1.80	....
B214	GS1	...	1.80	3.80	..	....
220	G3	...	...	10.00	..	....
319	SC8	3.50	6.30	...	..	....
355	SC21	1.30	5.00	0.50	..	....
356	SG1	...	7.00	0.30	..	....
360	SG3	...	9.50	0.50	..	....
A360	SG2	...	9.50	0.50	..	....
380	SC7	3.50	9.00	...	..	....
A380	SC6	3.50	9.00	...	..	....

[a] The nominal composition and alloy designations are those of Aluminum Company of America.
[b] Frontier Bronze Corporation.

TABLE 2 MECHANICAL PROPERTIES OF COMMONLY USED ALUMINUM CASTING ALLOYS[a]

Commercial designation	ASTM designation	Minimum: Tensile strength, psi	Minimum: Elongation % in 2 in.	Typical: Yield strength[b] psi	Typical: Tensile strength, psi	Typical: Elongation % in 2 in.	Typical: Bhn, 500 kg load 10 mm ball	Typical: Shear strength, psi	Typical: Endurance limit, psi
Sand-Casting Alloys									
40E	ZG41, aged	30000	3.0	25000	35000	5.0	75	26000	9000
43	S1, as cast	17000	3.0	9000	19000	6.0	40	14000	6500
113	CS22, as cast	19000	Not req'd	15000	24000	1.5	70	20000	9000
122-T2	CG1, H.T. 1	23000	Not req'd	20000	27000	1.0	80	21000	9500
122-T61	CG1, H.T. 2	30000	Not req'd	30000	40000	<0.5	115	29000	8500
142-T21	CN21, H.T. 1	23000	Not req'd	18000	27000	1.0	70	21000	6500
142-T61	CN21, H.T. 2	32000	Not req'd	32000	37000	<0.5	105	32000	8000
195-T4	C1, H.T. 1	29000	6.0	16000	32000	8.5	60	24000	6000
195-T6	C1, H.T. 2	32000	3.0	24000	36000	5.0	75	30000	6500
195-T62	C1, H.T. 3	36000	Not req'd	30000	40000	2.0	95	31000	7000
195-T7	C1, H.T. 4	29000	3.0	19000	....	.....	.....	....	....
214	G1, as cast	22000	6.0	12000	25000	9.0	50	20000	5500
B214	CS1, as cast	17000	Not req'd	13000	20000	2.0	50	17000	....
220-T4	G3	42000	12.0	25000	46000	14.0	75	33000	7000
319-F[c]	SC8, as cast	23000	Not req'd	18000	27000	2.0	70	....	10000
319-T6	SC8, H.T. 2	31000	1.5	24000	36000	2.0	80	....	10000
355-T51	SC21, H.T. 2	25000	Not req'd	23000	28000	1.5	65	22000	7000
355-T6	SC21, H.T. 1	32000	2.0	25000	35000	2.5	80	30000	8500
355-T71	SC21, H.T. 3	30000	Not req'd	29000	35000	1.5	75	....	10000
356-T51	SG1, H.T. 2	23000	Not req'd	20000	25000	2.0	60	18000	7500
356-T6	SG1, H.T. 1	30000	3.0	24000	33000	4.0	70	27000	8000
Permanent-Mold Alloys									
43	S1, as cast	21000	5.0	9000	24000	9.0	45	18000	....
A108	SC1, as cast	24000	Not req'd	16000	28000	2.0	70	25000	....
113	CS22, as cast	24000	Not req'd	19000	28000	2.0	70	23000	....
122-T551	CG1, H.T. 1	30000	Not req'd	35000	37000	< 0.5	115	27000	8500
122-T65	CG1, H.T. 2	40000	Not req'd	36000	48000	< 0.5	140	30000	9000
A132-T551	SN41, H.T. 1	31000	Not req'd	28000	36000	0.5	105	24000	....
A132-T65	SN41, H.T. 2	40000	Not req'd	43000	47000	0.5	125	27000	....
138	CS21, as cast	26000	Not req'd	24000	32000	1.5	100	22000	....
142-T571	CN21, H.T. 1	34000	Not req'd	34000	40000	1.0	105	26000	10500
142-T61	CN21, H.T. 2	40000	Not req'd	42000	47000	0.5	110	31000	9500
152-T524	GS23	27000	Not req'd	16000	29000	1.0	95	22000	....
B195-T4	CS4, H.T. 1	33000	4.5	19000	37000	9.0	75	30000	9500
B195-T6	CS4, H.T. 2	35000	2.0	26000	42000	5.0	90	32000	10000
B195-T7	CS4, H.T. 3	33000	3.0	20000	39000	4.5	80	....	....
A214	GZ1, as cast	22000	2.5	16000	27000	7.0	60	22000	....
B214	GS1, as cast	19000	Not req'd	13000	22000	2.0	55	....	....
319-F[c]	SC8, as cast	28000	1.5	19000	34000	2.5	85	24000	....
319-T6	SC8, H.T. 2	34000	2.0	27000	40000	3.0	95	....	....
355-T6	SC21	37000	1.5	27000	43000	4.0	90	30000	9000
356-T6	SG1, H.T. 1	33000	3.0	27000	40000	5.0	90	....	....
Die-Casting Alloys									
13	S5	....	.....	21000	39000	2.0	.....	....	19000
43	S4	....	.....	16000	30000	9.0	.....	....	17000
85	SC2	....	.....	24000	40000	5.0	.....	....	22000
360	SG3	....	.....	27000	44000	3.0	.....	....	19000
A360	SG2	....	.....	23000	41000	5.0	.....	....	18000
380	SC7	....	.....	26000	45000	2.0	.....	....	20000
A380	SC6	....	.....	25000	46000	3.0	.....	....	19000

[a] The alloy and temper designations and mechanical properties are those of the Aluminum Company of America.
[b] Compression yield strength generally considered to have same value as tensile yield strength.
[c] "As-cast" temper.

only can effect an improved structure, but at the same time can also generally reduce unnecessary expense in producing a casting. Frequently the same features of faulty design which give trouble to the foundryman and result in high costs will also affect adversely the service life of the structure. Some shortcomings of poor design may be overcome by advanced foundry technique, but the design engineer cannot rely upon the foundry to produce castings with maximum soundness and mechanical properties unless some of the basic principles of the casting and solidification of metal are incorporated in his design.

One of the fundamental problems which confronts the foundryman in the production of a cast shape is the establishment of a sequence of solidification so that the change in the unit volume of the metal on solidification can be compensated for satisfactorily. Risers, or metal reservoirs, are attached to the casting to provide the required feed metal and insure internal soundness of the casting itself. Proper gating, risering, pouring temperature, pouring speed, and the use of chills are some of the expedients used to obtain the required directional solidification. The designer should strive to design sections which are tapered in such a manner that they increase toward the points accessible to the feed metal. If tapered sections are not practical, a uniform section thickness should be maintained. When it is necessary to use a design in which light and heavy sections join, a gradual increase in thickness of the thinner section toward the point of junction is an advantage. Castings containing nonuniform sections improperly filleted or tapered

are prone to develop cracks as a result of residual stresses formed during solidification. Shrinkage and shrinkage cavities tend to occur in sections which are not designed to allow progressive solidification of the molten metal.

MECHANICAL PROPERTIES

The mechanical properties of the aluminum casting alloys are normally based on tests of individually cast specimens having a test section of $^1/_2$-in. diam. The properties listed in Table 2 are based upon test results from such specimens. The test-bar casting has been designed to provide optimum reproducible results and to reflect any changes in composition, metal-handling practices, or heat-treatment which may have occurred in its production. Therefore when such specimens are poured with a casting and accompany the casting through subsequent operations, they do provide some check on casting quality. However, the properties of such separately cast test specimens do not necessarily represent the properties which would be provided by the castings and may be either higher or lower, depending on a number of factors which influence the solidification rate of the metal in the mold. For example, test specimens machined from a heavy section of a casting may provide lower properties than the separately cast specimens, because the rate of solidification is relatively slow. Conversely, the rapid solidification rate of thin sections may result in the castings having higher mechanical properties than is shown by the separately cast test specimens. This condition is not peculiar to aluminum alloys but is true to various degrees of all cast metals.

Because of the effect of rate of solidification on the mechanical properties, the properties of test specimens machined from a single casting will also vary, depending on the location from which they are taken. Many purchasing or engineering specifications recognize this factor today and require an average tensile strength and elongation of at least one specimen machined from the heaviest, intermediate, and lightest section of a casting to be not less than 75 per cent and 25 per cent, respectively, of the minimum values specified for individually cast specimens. There is no general rule by which such factors can be determined, and the engineer, through experience, must develop the proper factor to apply to the properties specified for an alloy in determining the design stress of the casting.

The mechanical properties and some physical characteristics of many of the aluminum alloys can be substantially improved by heat-treatment, and a number of such treatments have been developed for castings as will be evidenced by a study of Table 2. Various combinations of strength and ductility may be obtained by variations in the heat-treatment procedure. In addition, some heat-treatments have been specifically developed to provide improved dimensional stability by reducing stresses and growth. These treatments are applied principally to sand and permanent-mold castings, although castings produced by the plaster-mold, precision-investment, or centrifugal casting processes can be so treated when desired. The limited use of heat-treatment for die castings is largely due to blistering of the castings which may occur as a result of the porosity that is inherent in the process, and the possible loss of desired dimensional accuracy.

SECTION THICKNESS

The low specific gravity of aluminum alloys and the adverse effect of a high pouring temperature on the metal structure limit the size of sections which can be cast satisfactorily. The minimum section thickness that can be cast depends upon the size, pressure requirements, intricacy of design of the casting, alloy, and the casting process. Extremely thin sections usually require pouring at high metal temperatures, often resulting in sacrificing desirable metallurgical structure with corresponding reduction in mechanical properties. The commercial limitations, with respect to section thickness, will be discussed under the various casting processes.

RIBS AND FILLETS

From the design standpoint, ribs and fillets are used primarily to improve the section modulus and act as stiffeners or reinforcing members. A more even distribution of the stresses from the applied service loads is realized from their correct use. The same factors influencing section thickness also govern the design of ribs. In addition to imposing casting difficulties, ribs designed too thin are subject to overstressing in the outer fibers. Consistent with economical molding practice, beads added to the outer edges of the ribs will reduce the outer fiber stress. In cases where beads are not practical, beneficial results may be obtained by designing the ribs with square rather than rounded outer edges. The possibility of ribs containing dross or voids, which would reduce their effectiveness, will be lessened if the casting is designed so that the ribs are cast in the drag or bottom part of the mold.

Generous fillets should be provided at all intersections and should be used between ribs and their supporting sections. Fillets adjoining two sections of equal thickness should have a radius at least the equal of the thickness. If the thickness of the larger of two adjoining sections exceeds the thickness of the smaller by more than 50 per cent, a gradual blending of the lighter section to the thickness of the heavier section should be used in addition to the fillets.

From the foundry standpoint, ribs are valuable in minimizing the tendency of large flat areas of castings to distort when cooling from the casting temperature. Fillets are also beneficial to the foundryman since they aid the flow of molten metal in the mold and minimize shrinkage and cracking. It is important for the designer to keep in mind that the improvement in section modulus which the use of ribs, fillets, and other built-up masses, such as bosses or lugs, is intended to provide, may be entirely lost if the design is such as to produce a metal mass that cannot be properly fed.

LOCATING POINTS

The design engineer should indicate on the drawing the locating points to be used by the machine shop in machining the casting. The same locating points can then be used by the pattern shop and the foundry to check the dimensions of the casting. The points should be as far apart as the size of the casting permits, preferably located on the same side of the parting line so that they will not be influenced by a shift of the core, the cope, or the drag. Jigs are frequently used by both the foundry and the machine shop for checking dimensions; the design of such jigs being based upon the locating points or dimensions which have close tolerances and a minimum of machine finish.

INSERTS

It is often desirable to cast inserts of other metals in aluminum castings to form wear-resisting surfaces. Cast iron or steel are the most suitable materials, although copper and brass are sometimes used but require that the foundryman takes proper care to prevent their solution in the aluminum. Because of the difference in coefficients of thermal expansion, the engineer should make certain sufficient metal is provided around inserts to withstand the stress developed as the aluminum shrinks during solidification. It is also essential that inserts be designed to have mechanical retention in the aluminum casting, as no metallurgical bond normally exists between the insert and the aluminum. Inserts to be used for transmit-

FIG. 2 HALF OF LARGE SAND MOLD LEAVING MOLDING MACHINE

ting high torque to the casting should have a series of slotted projecting legs or dogs spaced radially around the insert to provide the required grip in the aluminum. Applications requiring inserts for bearing purposes or for transmittal of light torque with no repeated reversals can be satisfactorily held by the use of knurled or shallow machine-grooved "keys" on the outer surface. Any of the commonly used casting processes allows the use of cast-in inserts, but the engineer should not overlook the fact that pressed-in or shrunk-in inserts will oftentimes suffice for bearing or bushing service and may provide a lower cost of assembly.

DESIGN FACTORS AFFECTING ECONOMICS OF MOLDING AND CORING

Parting lines should be made as straight as possible, the cost of producing castings with an uneven parting line generally overbalancing the cost of redesign to obtain an even parting line. Deep pockets and small recesses complicate the molding and add to the cost of cleaning. Similarly, small holes should be avoided in the interest of economy, particularly if tolerances are not close enough in the cast hole and subsequent reaming or boring must be employed for the finished casting

The ideal design of a sand casting is one that can be molded in green sand, and if a core is necessary, molded so that the pattern leaves its own green-sand core. The use of external and internal cores often adds materially to the cost of the casting; therefore, in so far as possible, parts should be designed to preclude cores, particularly internal dry-sand cores. Both internal and external dry-sand cores require anchoring to prevent shifting when the metal is poured. When practical, cores should be supported and anchored by core prints. Cores for semipermanent-mold castings are similarly supported. Holes in castings formed from core prints and necessary core-vent and cleanout holes may be placed to coincide with functionally designed openings of the casting. Any unnecessary holes may be plugged or welded during finishing or machining.

Chaplets for supporting cores are sometimes necessary in addition to, or in lieu of, core prints. They should be avoided whenever possible, particularly in castings which are required to be pressure-tight, since leakage will usually occur around such chaplets.

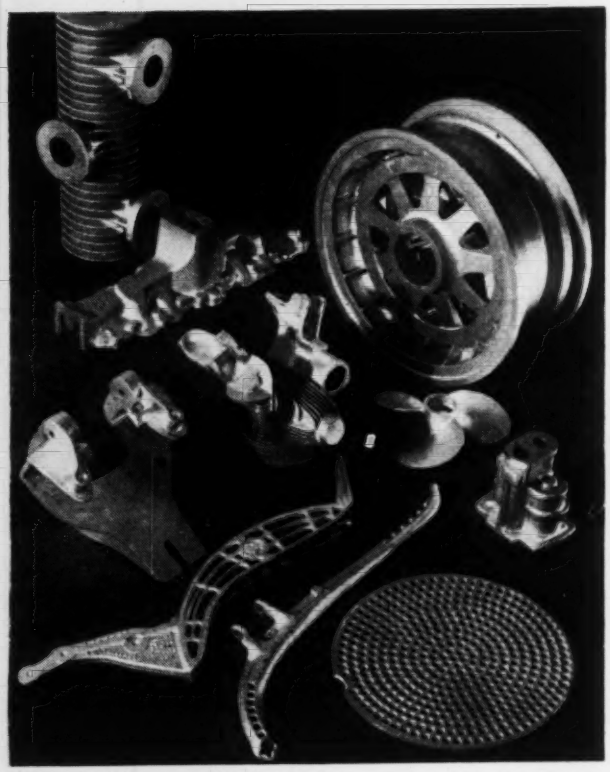

FIG. 3 A FEW CASTINGS PRODUCED BY SAND-CASTING PROCESS

Significant economies can be realized in the cleaning and finishing costs of castings provided these operations are considered during the design. Positioning of the parting line, so removal of the gates and parting line flash can be facilitated, should be kept in mind. Necessary risers for feeding heavy sections in inaccessible spots are removed with difficulty and at added expense. Unnecessary costs may be eliminated by the foundry in hand-finishing operations of casting surfaces which are to be machined subsequently, if such surfaces are clearly marked on the drawing supplied to the foundry.

DESIGNING FOR CASTING PROCESSES

The design engineer is responsible for the shape of the structure, and, in order for the foundryman to produce castings with maximum soundness and uniformity, the close co-operation of the designer with the foundryman is paramount. Each of the various casting processes offers its own potential advantages, but too frequently the design engineer does not obtain the advantages because of failure to consult the supplier during the development of his design. It will be to every designer's advantage to consider the casting process with his other factors when developing a casting design. In short, it is easier and less costly to select an alloy and design a part to a particular process than to modify it later. The following section is intended to assist the designer in selecting the proper casting process, and to provide further engineering details about each process.

CASTING PROCESSES

As mentioned previously, there are several casting processes adaptable to aluminum alloys, and the choice of the process best suited to any particular application depends on both technical and economic considerations in addition to the functional design requirements. Of these processes, three account for the major production, namely, the sand-casting process, the permanent and semipermanent-mold process, and the die-casting process. In the year 1942 the shipment of aluminum-alloy castings fabricated by the sand-casting process was approximately 64 per cent of the total, the permanent-mold process and the die-casting process accounting for about 19 per cent and 17 per cent, respectively.[3] The trend now being encountered for increased production by the permanent-mold process is illustrated by the fact that comparable values for the year 1946 show the permanent and semipermanent-mold production increased to 39 per cent, while the sand-casting production was reduced to about 41 per cent; die casting remaining about constant at 19 per cent, and the other casting processes employing aluminum accounting for the balance of 1 per cent.[3]

Sand Castings. The sand-casting process is the most versatile method of casting, primarily because of its universal adaptability. This process is generally employed for the production of (1) small quantities of identical castings; (2) parts requiring intricate coring; (3) large castings; and, (4) castings of a design suitable to modern high-speed molding equipment where production costs lower than for other methods can be established. Sand castings weighing from a few ounces to 500 lb are commonly produced, while castings up to 7000 lb have been made.

A suitable pattern, incorporating the required allowances for shrinkage and subsequent finishing, is employed in this process to produce the expendable sand mold. When dry-sand cores are required, core boxes, and driers are generally necessary. Such equipment has somewhat lower initial cost than equipment for certain of the other processes discussed later, but, at the same time, also provides a more limited life. Production rates are controlled by the type of pattern equipment as well as by the molding equipment, and may be from a few parts per hour for large castings using loose-pattern equipment, to several hundred per hour, for small castings using metal-match-plate equipment.

The minimum section thickness which can be cast in sand depends on the size, pressure requirements, and intricacy of the design of the casting. Although sections on the order of $\frac{1}{8}$ in. have been produced in small castings, $\frac{3}{16}$ in. is generally considered the minimum for small- and medium-sized parts.

Some sand castings are cast with sufficient accuracy so that no machining or finishing is required for their ultimate use over that normally done as a finishing operation by the foundry. The size tolerance is affected by the size of the casting, type and accuracy of pattern equipment, and molding technique. The designer can expect only extremely close tolerances with highly specialized production items, and then generally with cost of the finished casting proportionally higher. Tolerances of $\pm\frac{1}{32}$ in. are practical for small castings, but greater tolerances are required for large castings. Closer dimensional tolerances are normally obtained by machining, and finish allowance for such machining is necessary. Normal practice is to provide about $\frac{1}{8}$ in. for such finishing on small- and medium-sized castings. Large castings usually require $\frac{1}{4}$ in. or more finish allowance, particularly on those surfaces cast in the cope of the mold. The engineer should, wherever possible, design the casting so that surfaces which are to be machined can be cast in the drag of the mold.

The physical characteristics of the sand, the quality of the pattern surface, and the molding technique primarily govern the surface smoothness of sand castings. Although relatively smooth surfaces can be obtained with fine sand, the use of

[3] "Facts for Industry," Bureau of Census, Industry Division, Department of Commerce, Washington, D. C., July 9, 1947.

such sands is limited to rather small castings, larger castings requiring somewhat coarser sand in order to provide the increased mold permeability necessary for better casting soundness. Aluminum sand castings have better surface smoothness than sand castings of the heavier metals. Since the requirements of surface smoothness of the casting will influence its cost, the engineer should consider carefully the necessity of specifying excessively smooth finish.

Permanent-Mold Castings. In this process, metal molds and cores are used, the metal being poured into the mold cavity under a normal gravity head. The semipermanent-mold process is a variation of this process, and greatly expands the use of the process by virtue of the use of dry-sand cores, thus overcoming many of the design limitations imposed by metal cores. Collapsible steel cores may be employed in certain cases to provide irregular or undercut cored surfaces. Permanent and semipermanent-mold parts from a few ounces to 20 lb in weight are common foundry products, although permanent-mold parts weighing up to 250 lb and semipermanent-mold castings weighing up to 500 lb have been produced. Permanent-mold castings are characterized by their metallurgical superiority, pressure tightness, superior surface finish, closer dimensional tolerances, and, for certain sizes or design, speed of production and cost per piece.

The metallurgical superiority of this process is due to the chill imposed by the metal mold, consequently providing a refinement of grain and reduction in porosity in the castings. This results in a substantial improvement in the strength over similar parts cast in sand. The casting of a properly designed part in a well-engineered metal mold is also conducive to the formation of favorable thermal gradients in the mold, allowing progressive solidification of the molten metal. Pressure-tightness of the castings is one of the characteristics which result from such favorable conditions in a permanent mold. Many applications demand this quality, and may influence the decision of a designer to select the permanent-mold process.

Mold equipment for permanent molds is usually constructed from a good grade of dense cast iron, the cavities being machined to the desired contour. Metal cores, when required, are usually machined from alloy steel. Sand cores for semipermanent molds are of the same general type as used for sand castings and require the same production equipment. The cost of such molds will depend on the complexity and the casting tolerances desired. Normally, this cost exceeds that of

FIG. 4 MOLDING EQUIPMENT FOR PRODUCING PERMANENT-MOLD CASTINGS

FIG. 5 A FEW CASTINGS PRODUCED BY PERMANENT AND SEMIPERMANENT-MOLD PROCESS

good sand-casting pattern equipment but can be justified where production requirements are sufficient. The usual practice is for the casting purchaser to pay for the original mold equipment, and the foundry to provide any necessary maintenance or replacement molds. This practice, of most permanent-mold producers, makes a further inducement to the design engineer to consider the permanent-mold process.

As with sand castings, it is difficult to define the minimum section thickness which can be provided by the permanent-mold process, because of the effect of size and intricacy of the casting. Although sections of the order of $1/10$ in. can be provided in certain castings, $1/8$ in. is usually considered the minimum. The minimum diameter of cored holes is considered $3/8$ in., but holes as small as $1/4$ in. diameter are possible in some cores.

The surface finish of permanent-mold castings is governed by the smoothness of the mold surfaces and the proper control of mold coatings, the use of such coatings being essential to this process. The finish is superior to that provided by sand castings and can generally be used without further processing. Surfaces produced by sand cores in semipermanent-mold castings are of course dependent upon the smoothness of the core.

Possible tolerances depend on the size and complexity of the casting and the location of the dimension involved with respect to moving members of the mold. Tolerances lower than those possible with sand castings are generally provided, ± 0.020 in. being commonly maintained for small castings. Tolerances are usually figured as $\pm 1/64$ in. for the first 1 in. or less plus 0.001 in. to 0.002 in. for each additional inch of length, depending on whether the dimension is affected by moving parts of the mold. Permanent-mold castings also permit reduced machine-finish allowances, because of the closer tolerances and smoother surface finish. Depending on the size of the castings, finish allowance of $1/32$ in. to $1/16$ in. is generally adequate. Draft allowances should be as generous as possible, with 1 to 2 degrees considered as minimum and 3 to 5 degrees as preferred. Metal cores must also be supplied with draft; however, the minimum and preferred draft may be about one half of those just quoted. The required tolerances and draft greatly affect the cost of a casting because of their influence on production rates.

Favorable costs for permanent-mold castings are more apparent when a large number of identical parts are produced, the cost of the mold being distributed to the greater number of parts. Low costs are apparent in certain size or design of casting because of increased production rates per man-hour. Potential savings in machining and finishing may even provide economies for small production runs sufficient to warrant the use of this process.

Die Castings. Ability to cast relatively thin sections, accuracy, uniformity of reproduction, and low costs per piece characterize the die-casting process. In the production of die castings, molten metal is injected into a metal mold or die under pressure. Air injection up to about 750 psi is utilized in the so-called "gooseneck" machines, whereas the "cold-chamber" machines, employing metallic-plunger injection, use pressures of 3000 to over 20,000 psi. Today, die-casting

FIG. 6 DIE INSTALLED IN A COLD-CHAMBER MACHINE FOR PRODUCING DIE CASTINGS

FIG. 7 A FEW CASTINGS PRODUCED BY DIE-CASTING PROCESS

equipment suitable for production of castings ranging from a fraction of an ounce to 20 lb is available. Castings have been produced whose over-all dimensions are 36 in. × 12 in. × 9 in., but castings with dimensions in one direction may exceed these, as castings up to 84 in. have been produced.

Heat-treated alloy-steel dies are required for the production of aluminum-alloy die castings, the engineering of which is best done by trained designers experienced with aluminum. Although the cost of this equipment may exceed that required for the other casting processes, it is usually justified when sizable quantities of parts are required, and the cost is offset by the high productivity of the process and the elimination of finishing and machining operations. As in the case of permanent molds, die-casting foundries normally provide maintenance and replacement equipment when necessary.

Consistent with the size and complexity of the castings the alloy used, and the required strength and rigidity, relatively thin and uniform sections are desirable in die castings. Castings having a major dimension of 6 in. can be produced with sections of 0.045 in. in thickness, while for castings whose largest dimension is 15 in., a section thickness of 0.080 in. is about minimum. Although larger castings require somewhat heavier sections, thicknesses in excess of 0.150 in. are seldom required for the casting process.

Because of the close tolerances usually desired in die castings, designers of such parts should consult the producer for exact tolerances with respect to each casting being designed. In this way, maximum advantage can be taken of the process in providing close tolerances where required, without complicating the production of the casting. Generally speaking, tolerances as low as 0.0015 in. per linear inch, but not less than 0.002 in. on any dimension can be maintained. On large castings, this tolerance can be further reduced to 0.0010 in. for each additional inch over 10 in. An additional tolerance of from 0.003 in. to 0.010 in. is generally allowed on the plus side for dimensions affected by the parting line of the die or other moving parts of the die. Flatness tolerances are generally determined by multiplying the longest dimension by 0.0015 in.

Metal cores may be used in this process to produce recesses and holes. Frequently such coring will reduce or entirely eliminate machining operations at a saving to the user. At the same time, such cores will make for lighter castings with superior metallurgical properties as a result of the increased chill provided by the steel cores. Holes from $^1/_{10}$ in. to over 1 in. diam. or cross section can be provided within certain depth limitations with proper draft allowance. External threads down to about 24 threads per in. can also be cast within certain tolerances.

The possible surface detail and surface finish of die castings is superior to that of any other form of aluminum casting. Most commercial die castings can be used with a minimum of finishing operations, attention to the surface of the casting at the parting line being generally all that is required. Faithfulness of reproduction of engraved or ornamental details is an outstanding advantage of this process.

Die-casting production rates will vary with the size and intricacy of the casting and dies, alloy, and size of machine used, large machines operating more slowly than small machines. Operating speeds up to 150 cycles per hr may be attained with both gooseneck and cold-chamber machines if the part being produced is simple and the die of small or medium size. Frequently, multiple-cavity dies can be designed to permit increased piece production per cycle.

Die castings have very favorable costs compared with those of permanent-mold castings, and frequently with sheet stampings, when large quantities of identical castings are involved. Substantial savings can be realized in metal costs due to the lighter unit weight permitted by the thinner sections. The dimensional accuracy, smooth surfaces, and ability to cast threads and core holes also makes for minimum finishing costs. In fact, excessive machining is undesirable since it will result in reduced strength with removal of the chilled surface skin.

Other Refractory and Metal-Mold Castings. There are several additional casting processes which are adaptable to aluminum alloys. In most cases these processes are modifications of previously discussed casting methods being developed to provide improved casting tolerances. Small precision castings, requiring a minimum of machine-tool man-hours for finishing, may be produced by these methods. Although the initial cost of such castings is frequently higher than that of castings

produced by the more common processes, the higher cost may be offset by savings in finishing. Therefore plaster-mold, precision-investment, and centrifugal castings may provide characteristics desired by the designer for certain specialty-type castings.

The plaster-mold-casting process is a refinement of the sand-casting process in which the normal molding sand is replaced by other nonmetallic materials, such as gypsum plaster, with the result that smoother mold surfaces and greater mold accuracy are possible. The plaster mold must be heated prior to use to drive off the water and is capable of producing but one casting, after which it is discarded. The process is generally confined to small castings under about 2 lb in weight, although considerably larger castings have been produced in limited quantities.

Since precision is the primary advantage of this process, metal-matchplate pattern equipment, and metal core boxes when necessary, must have greater accuracy than that required for sand castings. Therefore the costs are greater than for similar sand-casting equipment, but generally less than that required for permanent-mold castings. Mechanical molding equipment is often used for large quantity production items, with resulting production rates about comparable to those of the permanent-mold process. Normally a gravity head is employed in pouring such molds, although moderate pressures are sometimes applied after pouring to obtain improved casting detail.

The mold materials generally used with this process provide a slower solidification of the metal than in normal sand or metal molds. This results in lower mechanical properties and tends to promote segregation of the alloying constituents. To minimize these disadvantages, aluminum-silicon alloys are generally employed in this process. A combination of the superior fluidity of the aluminum-silicon alloys and the nature of the mold material provide the opportunity to obtain a smooth surface finish and thin sections.

The precision-investment-casting process also utilizes a nonmetallic-type mold, generally gypsum plaster, but employs an expendable wax pattern produced in a master mold instead of the usual permanent pattern. The wax pattern is completely enrobed or invested in the molding material and is subsequently melted out of the mold after having formed the required cavity. The heating required for melting out the wax pattern is generally combined with the necessary operation of removing the excessive water from the plaster itself, this being required to put the plaster in a condition to receive the molten metal. Castings of this type are usually poured under pressure, or use the centrifugal process or vacuum to supply pressure immediately after the metal is poured.

Accuracies approaching those of die castings are possible with this process in many cases, and because there are no moving mold or die members to interfere, accuracies in other cases may be superior. The use of pressure to fill the mold cavity also insures a sharpness of detail commensurate with that of die castings, subsequent machining of these castings being generally reduced to a minimum. Because most castings produced by this method are of very small size and light section, the effect of the slow cooling imposed by the mold is not sufficient to affect greatly the mechanical properties or alloy choice. Although most of the aluminum casting alloys can be used for small castings, the aluminum-silicon alloys are preferred for larger-sized castings.

The centrifugal casting process utilizes centrifugal force in a revolving mold to fill the mold cavity. This process has been popular with various ferrous and nonferrous alloys because of the cleansing of the metal of oxides and inclusions by the centrifugal action and the resulting improved mechanical properties. Similar separation of inclusions in aluminum castings by centrifugal action is limited because of the small difference in the specific gravity between the various oxides and inclusions associated with aluminum alloys and the molten metal. It is questionable therefore whether improved mechanical properties can be provided over those obtained by the normal casting procedures. Centrifugal casting of aluminum alloys has had but limited use up to the present time, and it remains to be demonstrated whether the process offers anything other than a means of pouring metal under pressure.

A true centrifugal casting is one which is substantially symmetrical about an open center and is produced from a mold which is rotated about a central axis. Semicentrifugal castings are also rotated about the central axis, but the mold contains a central core used to form the contour of the bore. Centrifuged castings are unsymmetrical or without a central hole and are rotated in a horizontal plane along the perimeter of a circle concentric with the axis of rotation. Sand, molding plaster, or metal molds may be used for all three types of centrifugal castings, although the strength limitations of sand molds limit their use. Metal molds are preferred for high production, but plaster molds are commonly used for small castings.

Mold equipment for centrifugal castings is essentially the same as for similar molds used for comparable gravity casting processes, and the cost of such equipment should be similar. The maximum size of casting produced appears to be limited only by the strength of the mold material and the centrifugal casting machine. To date most production has been confined to small castings.

Depending on the smoothness of the mold surface, centrifugal castings should have superior surface smoothness and sharpness of detail to castings produced in similar mold equipment under gravity. The outstanding advantage appears to be the possibility of casting thin sections at low metal temperature, a condition which should reflect favorably on mechanical properties.

CONCLUSIONS

The properties and inherent characteristics of the aluminum alloys themselves account for the use of aluminum castings for many applications, but in other cases the several commercial processes by which such alloys can be cast provide important economic advantages. In order to realize these advantages to the maximum, the basic casting-design limitations, together with the advantages and disadvantages peculiar to each of the casting methods, should be considered during the early stages of casting design. It cannot be overemphasized that during all stages of design, close co-operation between the design engineer, and the producing foundry is essential.

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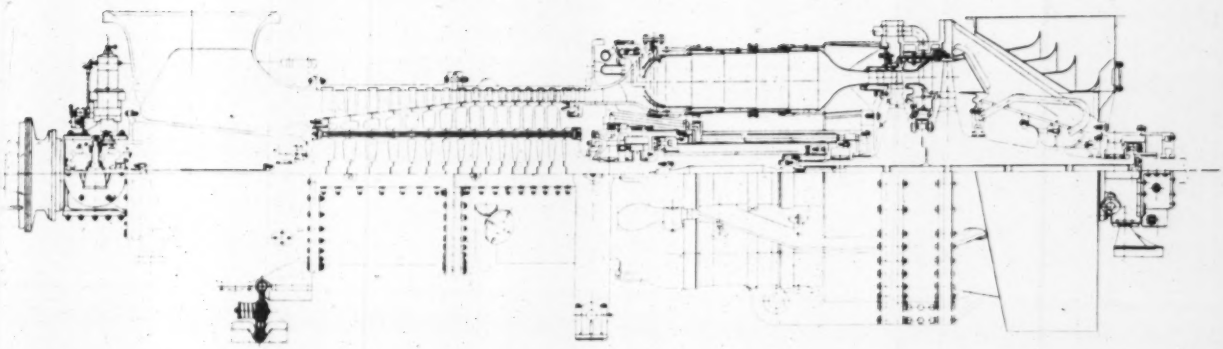

FIG. 1 LONGITUDINAL SEMISECTION OF GAS TURBINE FOR LOCOMOTIVE DRIVE

The GAS TURBINE *With a* WASTE-HEAT BOILER

By GEORGE R. FUSNER

GAS TURBINE ENGINEERING DIVISION, GENERAL ELECTRIC COMPANY, SCHENECTADY, N. Y. JUNIOR ASME

A SINGLE-SHAFT gas turbine with no exhaust-heat-recovery apparatus is good for many applications but where fuel cost is a predominant factor, it is not satisfactory. At high loads, however, the large volume of exhaust gas carries away much heat energy. One way to improve the plant heat rate is to pass the exhaust gas through a waste-heat boiler to produce steam for process, heating, or electric power generation.

The application of a simple waste-heat boiler has been suggested in previous papers but in practice the system leaves much to be desired. Major drawbacks are the interdependence of electric power and steam generation, and a decreased steam production with low ambient temperatures. This paper describes methods of overcoming these handicaps.

To illustrate the value of this application a 3500-kw simple-cycle gas turbine has been chosen. It is of the same general type as the locomotive gas-turbine power plant described in a previous paper[1] but with different performance characteristics. It will operate at a constant speed when carrying load.

Fig. 1 shows a cross section of the locomotive power plant. An outline of the proposed 3500-kw gas-turbine power plant is shown in Fig. 2.

At the design point of this power plant, with a boiler of 75 per cent effectiveness, it is possible to generate 31,200 lb per hr of 50-psig saturated steam or 25,600 lb per hr of 200-psig saturated steam from the exhaust gases. If the 85.5 lb per sec of gas could be cooled down to the saturation temperature of the steam, 43,000,000 Btu per hr would be available to generate 50-psig saturated steam and 38,000,000 Btu per hr would be available for 200-psig saturated steam.

[1] "Design Features of 4800-Hp Locomotive Gas-Turbine Power Plant," by Alan Howard, MECHANICAL ENGINEERING, vol. 70, April, 1948, pp. 301–306.

Contributed by the Gas Turbine Power Division and presented at the Semi-Annual Meeting, Milwaukee, Wis., May 30–June 5, 1948, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

DESCRIPTION OF WASTE-HEAT BOILER

Fig. 3 is a sketch of one type of waste-heat boiler for this application. This boiler has 8500 sq ft of heating surface arranged 20 tubes wide and 70 tubes deep. The 2-in. tubes are rolled into a 48-in. upper and a 32-in. lower drum. Distance between drums is 13 ft 6 in. Approximate over-all dimensions are height 20 ft, width 8 ft, and length 25 ft. After investigation, the author has confidence that such a boiler can be purchased for approximately $75,000.

CONVENTIONAL OPERATION

The exhaust temperature of the simple-cycle gas turbine decreases as the ambient temperature decreases. Values for the 3500-kw turbine are shown in Fig. 4. At 3500-kw generator output, the exhaust temperature with 80 F ambient is 820 F and at 0 F ambient the exhaust temperature will drop to 610 F.

This lower exhaust temperature naturally results in less steam being generated in the waste-heat boiler. The variations for the 200-psig saturated steam are shown in Fig. 5, and the 50-psig steam in Fig. 6. These curves were calculated on the basis of water entering the boiler as saturated liquid at 0 psig pressure and a constant boiler effectiveness of 75 per cent, which includes a 3 per cent radiation loss. Boiler effectiveness is defined as the ratio between the actual gas enthalpy drop and that which would be obtained if the gas were cooled down to the temperature of the leaving steam.

It can be seen from Fig. 5, that the output of steam generated drops from 25,600 lb per hr at 3500 kw and 80 F ambient to 15,600 lb per hr at 0 deg F ambient. Since the turbine temperatures vary with load, the amount of steam generated also varies proportionately. For example, at 80 F ambient, 31,200 lb per hr of 50-psig saturated steam is generated at the full load of 3500 kw, but, at no load and the same ambient, the amount of steam generated falls to 9500 lb per hr.

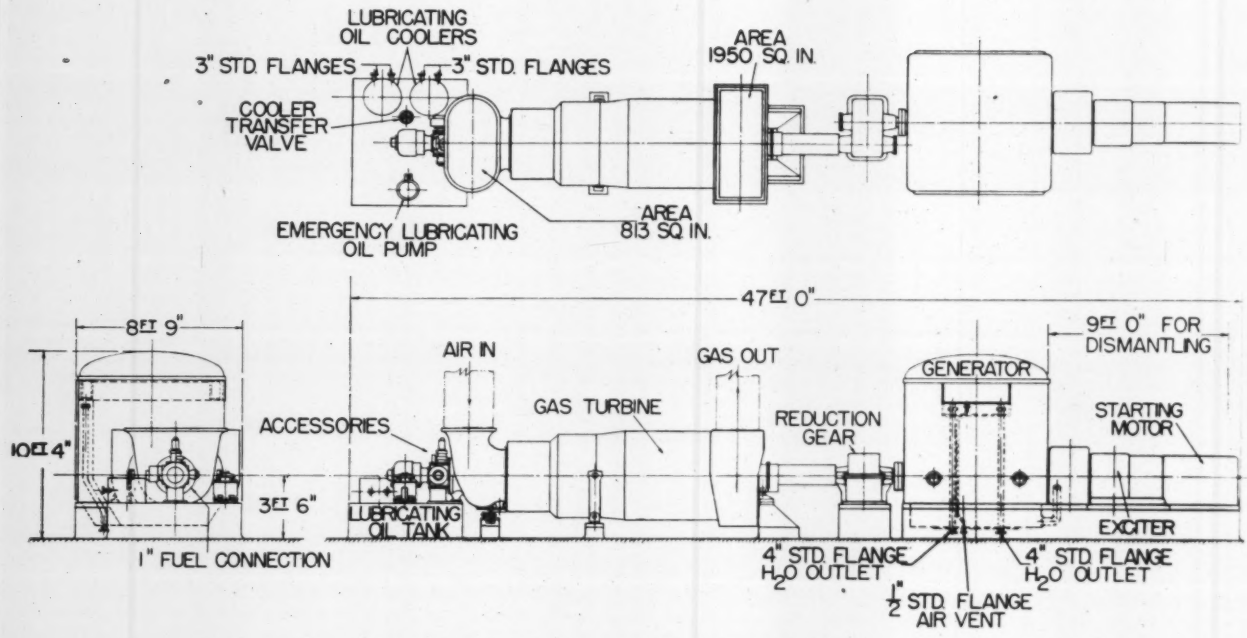

FIG. 2 OUTLINE OF LOCOMOTIVE-DRIVE GAS TURBINE INSTALLED AS STATIONARY POWER PLANT

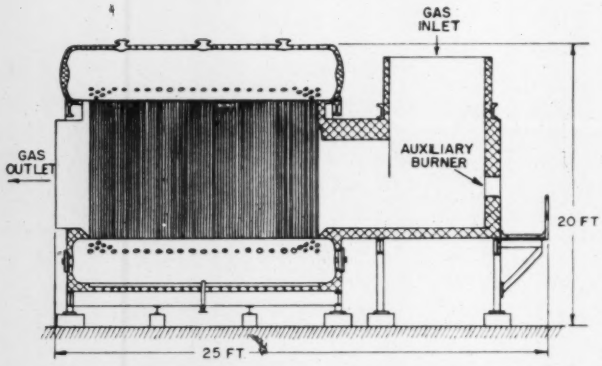

FIG. 3 GENERAL ARRANGEMENT OF WASTE-HEAT BOILER

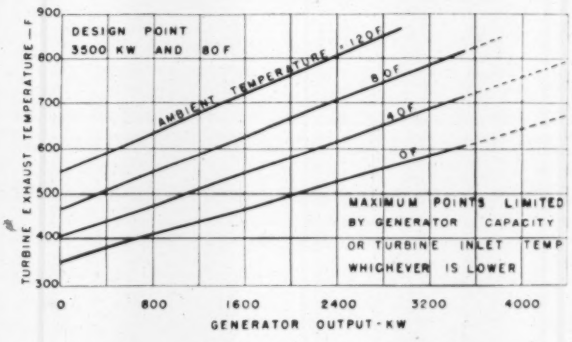

FIG. 4 SIMPLE-CYCLE GAS-TURBINE EXHAUST TEMPERATURE VERSUS GENERATOR OUTPUT AND AMBIENT TEMPERATURE

OPERATION WITH INCREASED TURBINE BACK PRESSURE

Several things can be done to modify this characteristic. One method of overcoming this problem is to place a valve between the gas-turbine discharge and the waste-heat boiler. The exhaust temperature can be regulated by throttling the turbine exhaust with this valve. When the turbine is throttled, more fuel must be burned in the combustors to maintain constant generator output. This results in an increased exhaust temperature. By this means it is possible to regulate the power and steam production over a wide range regardless of ambient temperature. For example, in zero weather 21 per cent more 200-psig steam can be generated than on an 80 F day with a power output of 3500 kw. This is obtained at the design exhaust temperature.

To illustrate this method of operation, the estimated characteristics of the 3500-kw power plant operating with a 0 deg F ambient temperature are plotted in Fig. 7. Characteristics for normal operation are shown for comparison. These curves show that 31,000 lb per hr of 200-psig saturated steam can be obtained at all generator outputs by throttling the turbine exhaust.

If the exhaust is not throttled, only 15,600 lb per hr is generated at 3500 kw, decreasing to no steam generated at 600 kw and below. To obtain the 31,000-lb per hr steam generation, the turbine exhaust pressure has to be raised to 3.8 psig at full load, and 11.3 psig at no load. At 3500 kw, the fuel flow is increased from 4100 lb per hr under normal conditions to 5300 lb per hr when generating the 31,000 lb per hr of steam.

The fuel flow at no load increases from 1950 lb per hr to 4600 lb per hr. When operating with the increased turbine back pressure the turbine-bowl (inlet) temperature must be raised from 1085 F to 1340 F under full load and from 685 F to 1200 F at no load to obtain this constant steam rate.

Although the turbine-exhaust temperature under throttled conditions is limited to the normal full-load design value, the average turbine temperature over a period of time is higher than it would be with no throttling. It is evident that the gas turbine must be designed properly to operate satisfactorily at this higher average (but not maximum) temperature.

OPERATION WITH AUXILIARY BURNER

Another method of obtaining increased steam flow from the waste-heat boiler is to use an auxiliary burner in the boiler.

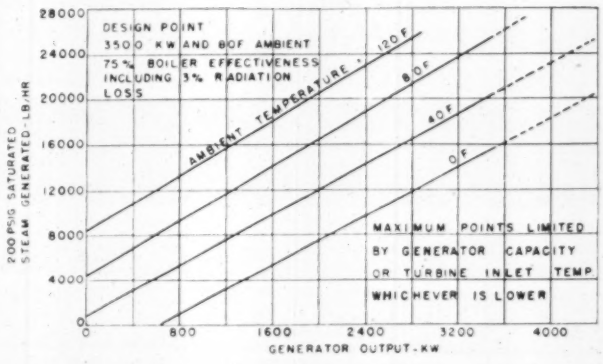
DESIGN POINT
3500 KW AND 80F AMBIENT
75% BOILER EFFECTIVENESS INCLUDING 3% RADIATION LOSS
AMBIENT TEMPERATURE - 120F
80F
40F
0F
MAXIMUM POINTS LIMITED BY GENERATOR CAPACITY OR TURBINE INLET TEMP WHICHEVER IS LOWER
200 PSIG SATURATED STEAM GENERATED - LB/HR
GENERATOR OUTPUT - KW

FIG. 5 200-PSIG SATURATED STEAM GENERATED VERSUS GENERATOR OUTPUT AND AMBIENT TEMPERATURE

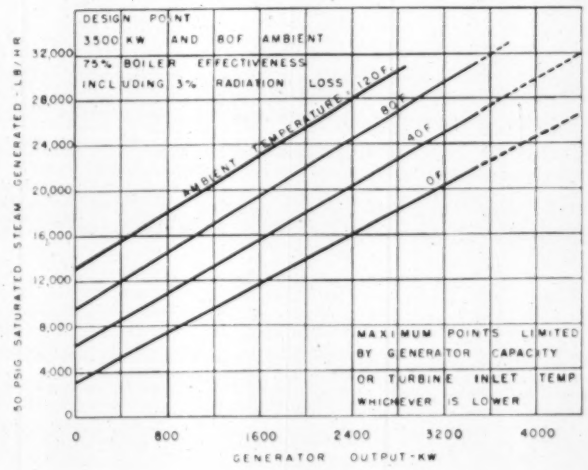
DESIGN POINT
3500 KW AND 80F AMBIENT
75% BOILER EFFECTIVENESS INCLUDING 3% RADIATION LOSS
AMBIENT TEMPERATURE - 120F
80F
40F
0F
MAXIMUM POINTS LIMITED BY GENERATOR CAPACITY OR TURBINE INLET TEMP WHICHEVER IS LOWER
50 PSIG SATURATED STEAM GENERATED - LB/HR
GENERATOR OUTPUT - KW

FIG. 6 50-PSIG SATURATED STEAM GENERATED VERSUS GENERATOR OUTPUT AND AMBIENT TEMPERATURE

This allows the turbine to be operated normally. The auxiliary burner shown in Fig. 3 can be used to increase the gas temperature far above the allowable turbine-exhaust temperature with a consequent increase in boiler output. By burning approximately 5000 lb per hr of oil in the auxiliary burner, the gas temperature entering the boiler would be 1800 F and 85,000 lb per hr of 200-psig saturated steam, or 92,000 lb per hr of 50-psig saturated steam would be generated. Thus, it is possible to get varying amounts of steam and electric power to suit the load requirements.

AUXILIARY BURNER VERSUS TURBINE THROTTLING

It should be clear that the same quantity of additional fuel is required to generate a given amount of additional steam, regardless of which system is used.

The auxiliary-burner system requires a separate fuel system, a primary-air supply, and provision for introducing the burner in or just ahead of the boiler. This system is limited in firing temperature by the boiler itself, and not by the turbine. A waste-heat boiler for this system may be either a fired or unfired pressure vessel.

A turbine throttling system requires a controlled throttling valve in the turbine exhaust. Since the additional fuel is burned in the gas-turbine combustors, no additional fuel or air supply is necessary. In this case, the maximum gas temperature entering the boiler is determined by the allowable

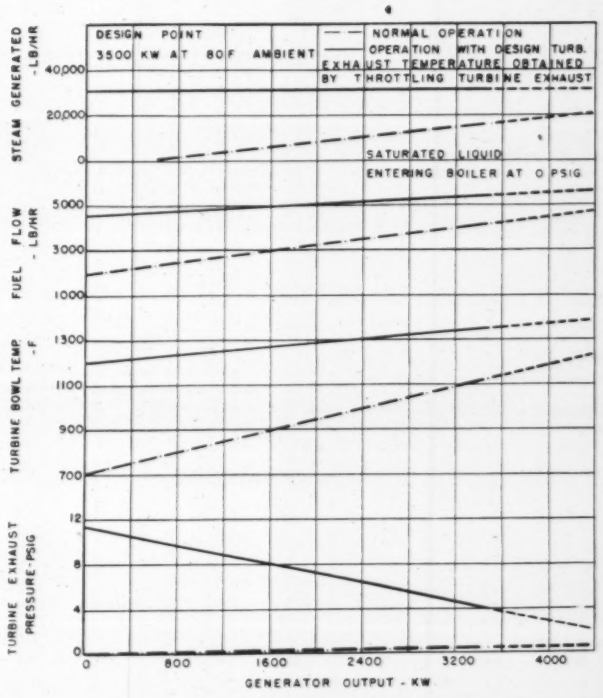
DESIGN POINT
3500 KW AT 80F AMBIENT
NORMAL OPERATION
OPERATION WITH DESIGN TURB. EXHAUST TEMPERATURE OBTAINED BY THROTTLING TURBINE EXHAUST
SATURATED LIQUID ENTERING BOILER AT 0 PSIG
STEAM GENERATED - LB/HR
FUEL FLOW - LB/HR
TURBINE BOWL TEMP - F
TURBINE EXHAUST PRESSURE - PSIG
GENERATOR OUTPUT - KW

FIG. 7 SIMPLE-CYCLE GAS-TURBINE PERFORMANCE CHARACTERISTICS OPERATING WITH A WASTE-HEAT BOILER GENERATING 200-PSIG SATURATED STEAM AT 0 DEG F AMBIENT TEMPERATURE

gas-turbine exhaust temperature. The waste-heat boiler is an unfired pressure vessel.

WASTE-HEAT EVALUATION

Table 1 shows the value of the waste-heat boiler for a typical plant. For illustration purposes, the summer load of 2500 kw and 25,000 lb per hr of steam have been assumed to be at the extreme temperature of 100 F, and the winter load of 3000 kw and 40,000 lb per hr of steam at 0 F. This means that on the average over the year 22,000 lb per hr of 50-psig steam could be generated by the waste-heat boiler with conventional operation. The remaining steam load can be obtained by the methods previously discussed.

Fig. 8 is used to calculate the value of the steam generated by the waste-heat boiler. This figure shows, for 50-psig saturated steam, the investment value of the waste-heat steam for various quantities, capacity factors, values of steam per million Btu, and amortization rates. For the typical plant data of Table 1, the investment value of the steam is $170,000, assuming 0.9 capacity factor, steam value of 25 cents per million Btu. and a 25 per cent amortization rate. The $170,000 may be

TABLE 1 VALUE OF WASTE HEAT RECOVERED IN A TYPICAL PLANT

	Summer	Winter
Extreme ambient temperature, deg F	100	0
Electrical load, kw	2500	3000
Steam load, lb per hr (50 psig)	25000	40000
Steam load which can be supplied by waste-heat boiler with conventional operation	25000	19000
	Average	22000
Steam load to be supplied by auxiliary burner and/or increased turbine-exhaust pressure	0	21000
	Average	10500
Value of steam supplied by waste heat with 0.9 capacity factor, value of steam, 25 cents per million Btu, and 25 per cent amortization rate	$170,000	

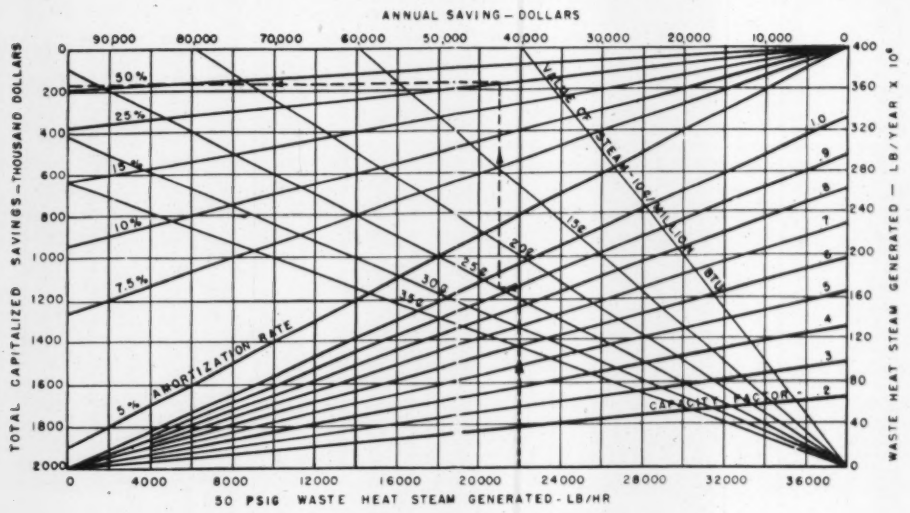

FIG. 8 VALUE OF 50-PSIG STEAM GENERATED

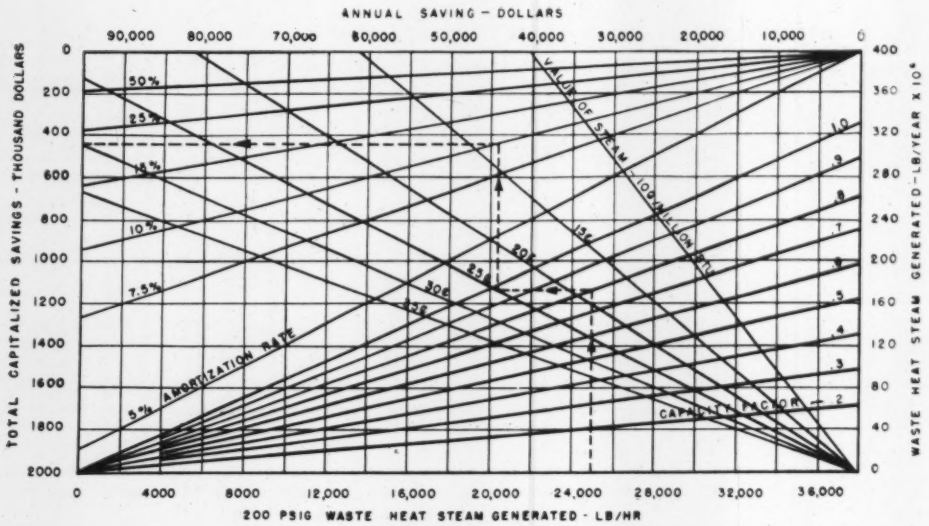

FIG. 9 VALUE OF 200-PSIG STEAM GENERATED

obtained by entering Fig. 8 at 22,000 lb per hr of steam, rising vertically to the 0.9 capacity-factor line, and then going left to the 25 cents per million Btu line. This shows the annual saving to be $42,500. Where the $42,500 line intersects the 25 per cent amortization line, the investment value is $170,000. If the boiler costs $75,000, there is a net saving of $95,000. Therefore, this justifies a higher investment in the gas turbine than normally would be thought economical.

Since the boiler normally operates at the low gas temperature of 820 F, it should have a long life. Therefore in all probability it can be fairly amortized over a 10-year period, which has a great effect upon the investment evaluation. In the case just discussed, the capitalized value of the steam would be increased from $170,000 or $48.60 per kw to $425,000 or $121.50 per kw. It is evident that, under favorable circumstances, the value of the waste heat is great enough to pay for the entire cost of the gas turbine.

From Fig. 9, the value of 200-psig steam generated from a waste-heat boiler can be calculated. It is similar to Fig. 8, except for the higher steam pressure.

APPLICATIONS

It is believed that this new application of the waste-heat boiler will meet with wide acceptance, both in the industrial and central-station power fields. This arrangement can fulfill the requirements of almost any industrial-process application where large quantities of process steam are needed in addition to electric power. Once more the independence of electric power and steam should be mentioned because it is probably the outstanding advantage of the system.

In addition to being good for continuous duty, the gas turbine should be excellent as a stand-by unit or for peak load where it can be used with a waste-heat boiler. The steam generated could be used in existing turbines which might be outdated for continuous service, but could be run for short periods. This would mean approximately 1500 kw additional electric power without additional steam-turbine investment costs.

There are many old power plants which have boilers that are being derated. Some of these could be used with minor alterations as waste-heat boilers for gas turbines. Thus, the investment cost of the boiler would be saved.

ACKNOWLEDGMENTS

The author is grateful to his colleagues, especially to Dr. C. J. Walker, for their advice and suggestions.

IT'S *the* LITTLE THINGS *That* COUNT

By A. F. MURRAY

WORKS MANAGER, ELECTROLUX CORPORATION, OLD GREENWICH, CONN. MEMBER ASME

A SMOOTHLY operating, low-cost, efficient, profitable production line is a matter not only of capital equipment (buildings, machinery, and tools) manned by skilled and co-operative personnel, but is dependent on little details in design of product, production tooling, and material handling to a greater degree than is usually realized. A few basic principles applying to these details will be discussed and illustrated.

Knowledge of the skills and equipment available to the producing factory, the time available before start of production, maximum daily production, total quantity to be produced, and life of design must all be carefully weighed.

BASIC REQUIREMENTS FOR SUCCESSFUL PRODUCTION

In design of the product itself the greater the volume, the more complete must be the specifications and control of the materials entering each stage of the production. The castings, sheet material, and so forth must be increasingly uniform in dimension and in machining or forming quality. The fabrication must be to closer tolerances, with tooling more and more fool-resisting and less susceptible to breakdown. Material handling must provide more and more direct flow so that errors may be caught without large quantities of defectives in stores or between operations. Also, equipment and organization must be flexible to minimize results of such errors, breakdowns, or changes which may occur.

Castings. These should be dimensioned and tooled with due regard to foundry or die-casting practice, so that variations caused by parting lines and shifting cores will not cause off-center cover plates or bolt-boss drilling, thick and thin walls, and the like.

Reduce to a minimum the number of directions from which the casting or other part must be machined. It is frequently possible to put hand-hole plates, setscrews or drain plugs in the same plane as major machining and make it unnecessary to turn over the jig or part or to machine in a special setup.

Shafts. Shafts should be dimensioned from one end, where possible, so that diameters and shoulders can be turned without a lot of shop mathematics by the lathe operator. If there are reference dimensions between shoulders for engineering or assembly purposes, put the machine-shop dimensions below the center line, and the engineering dimensions above, or vice versa. Where undercuts are necessary, make one or both sides at a 30- or 45-deg angle if possible, to strengthen the undercutting tool and also make a very small radius in each corner if feasible.

Sheet-Metal Boxes or Cabinets. In the design of these items, where a range of sizes is being made, it is frequently possible to make corner radii, foldover dimensions, size and spacing of holes, size of special cutouts, standard for the entire line. This will permit a single set of radius bars, brake stops, and multiple-piercing dies to be kept set up with little or no change-over time, even if size of individual lots is small and on a made-to-order basis.

Hole Layouts. Frequently, these can be simplified to reduce the number of sizes. There is little difference in cost of screws, nuts, or rivets in sizes between $\frac{1}{8}$ in. and $\frac{1}{4}$ in., and frequently a design can, for instance, be made all No. 10 instead of No. 6, No. 8, and No. 10. Three sizes of screw holes mean setting up three drill spindles for tap-size drill, three spindles for tapping and, in the corresponding piece, three spindles for clearance holes, and sometimes three more for counterboring or countersinking, making a total of 9 or 12, instead of 3 or 4. Even in small-quantity production, this is a large factor in cost, requiring three sizes of bushings in the drill jig itself, increased time of setup, reduced department production, and increased power consumption by idle time of the extra spindles. In addition, extra labor is necessitated because the operator must walk along a gang of drills instead of standing still in front of one; three containers and specially bladed screw drivers are needed on the assembly bench, and extra time is required to insert screws. All this may represent several thousand dollars of extra equipment in drill spindles, tied up during operations on small-quantity production, or continuously invested on a straight-line setup. Even if multiple-drill heads are used, the most efficient speed probably will not be possible for all sizes and assembly, and stock difficulties remain.

Choice of Materials Is Important. For instance, castings, metal stampings, and molded plastics all have certain advantages, both from product and manufacturing angles. Periodic review of designs and careful analysis of new designs should always be made before selecting the process. It has been found that the postwar answer is different in many cases from the prewar answer. Improvements in technique and in the physical properties of the basic materials will permit new applications. The price-structure differentials are also changed. Aluminum has become more plentiful and basically lower in cost. Both steel and plastic resins have been and probably will continue for some time to be in short supply and considerably above prewar price. Labor base rates are so much higher that previous distribution of total cost between labor and material has been radically altered. The author has found it profitable in a number of cases to retool for aluminum die-casting a number of parts which had previously been made from sheet metal by the use of metal-stamping operations, spot welding, and plating.

In our particular situation, this procedure has had several additional fortunate by-products. It has enabled us to utilize what supplies of steel we have been able to obtain, and to produce a larger number of sets of parts by reducing the number of steel parts in each set. It also has acted in the same way with reference to pressroom and plating-room capacity and has permitted us to utilize the facilities of commercial die-casting companies to supplement our factory floor space. The reduced number of operations remaining for us to do on a die casting, as received in the plant, means much less accumulation of parts in

Contributed by the Machine Design and Production Engineering Divisions and presented at the Annual Meeting, Atlantic City, N. J., December 1–5, 1947, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

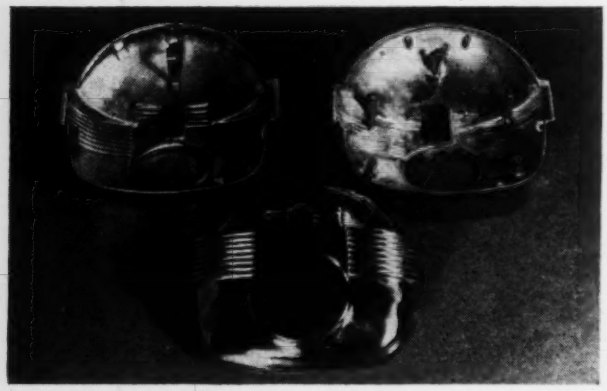

FIG. 1 DIE-CAST VACUUM-CLEANER FRONT COVER

FIG. 2 PRESS OPERATIONS IN METAL-STAMPING A FRONT COVER

Fig. 4 shows some of the operations required to make the metal stamping. It was an extremely difficult series of operations with high die maintenance, requiring specially selected deep-drawing material to stand the severe draws without splitting. One of the earlier objections to making this part from a die casting was the fact that the design shape required more than half a sphere, and it was believed that a machining operation would be required because the part otherwise could not be ejected from the die-casting mold.

Investigation developed the fact that ductile alloys had become available, and the necessary shape could be obtained without machining other than by one simple swaging or curling operation in a punch press on a finished die casting.

A series of sprayer-unit designs are shown in Fig. 5. In the original design, at the left, the sprayer tops consisted of a series of brass stampings soldered together, with a considerable amount of buffing and polishing in addition to plating.

This was replaced with a design, at the right, in which a one-piece plastic top, requiring no plating or polishing, was substituted for the metal top, giving a better result at lower cost. Unfortunately plastic resins became almost entirely unobtainable, and an alternative design using die castings was made. It was found that if the die casting could be used, with merely a removal of flash and light shot-blasting, giving a dull finish, there was very little difference in manufacturing cost. This design is shown adjacent to the metal top at the left. It was found, however, that, if the top were to have as pleasing an appearance as the plastic top, the necessary polishing increased the cost so much as to make this design only desirable for emergency use. This was so in spite of certain modifications to the outside shape to eliminate sharp corners and small radii which

FIG. 3 METAL-STAMPED AND DIE-CAST ROUND-BRUSH OR DUSTING BODIES

process and, therefore floor space is made available for increased production of other parts.

TYPICAL APPLICATIONS OF PRINCIPLES

The front cover of the vacuum cleaner made by the author's company is a good example of advanced production practice. Originally a metal stamping, requiring 16 press operations on the major stamping, nine metal clips of five types spot-welded in five operations, and one drilling operation, was used. This was replaced by the present one-piece die casting with cast-in holes for drive screws, shown in Fig. 1. No operations except polishing and buffing were required.

An additional problem solved by this change-over was that spot-welding of the clips to the steel stamping frequently caused burn-out depressions on the outside surface, which resulted in excessive grinding and extra cost in the polishing operations.

Some of the more difficult press operations in making the metal stamping of the front cover are illustrated in Fig. 2.

Another example is a round-brush or dusting-brush body. Fig. 3 shows a top view of the finished part, and a bottom view of the metal stamping, and one of the die casting which supersedes it.

FIG. 4 STEPS IN METAL-STAMPING OPERATIONS FOR ROUND-BRUSH BODY

seriously affect the costs of the polishing operations.

Fig. 6 shows a before-and-after change on an upholstery-cleaner die casting. To the casual observer there is no difference. However, a careful examination will show that the

bottom lip of one has been thickened sufficiently to raise it above the vent slot, so that under on circumstances will there be any sharp edges around this slot requiring extra work for removal.

The character of the trade-mark lines has been changed to include a slight radius in the bottom corners of all the letters and lines. This makes the buffing compound wash out in the cleaning operation without the necessity of using a scrubbing brush to clean the corners. In the revised design, the trade-mark was raised slightly in relation to the lip, so that no part of the circle would be close to the blending radius between the main body and the lip. These apparently trivial changes made an actual difference of 4 cents each in the finishing cost of this item. At our present production rates, this means several thousand dollars saving per month.

A fan housing made of sheet steel from a square blank is shown in Fig. 7. When these housings were zinc-plated after fabrication, in the conventional still tanks, the plating operator tilted the parts on removal from each solution to drain any pockets. When an attempt was made to apply automatic

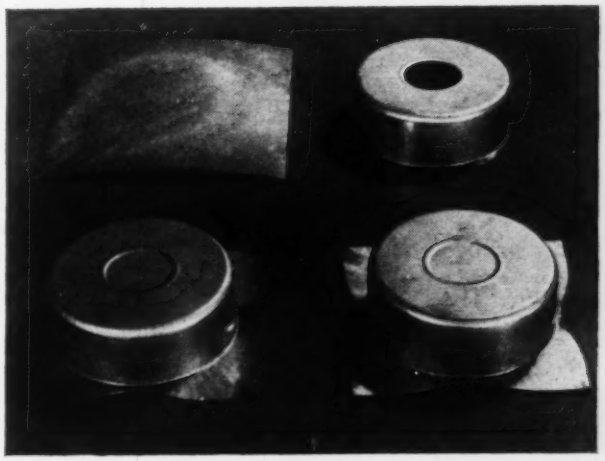

FIG. 7 FAN-HOUSING-STAMPING SERIES

FIG. 5 EVOLUTION OF SPRAYER UNITS

FIG. 6 BEFORE-AND-AFTER CHANGES IN UPHOLSTERY-CLEANER DIE CASTING

plating, it was found that they were not self-draining and rapidly contaminated the solutions when racked in the previous manner. If racking were done so that the parts would be self-draining, a gas pocket developed, with inferior plating on the upper inside portion. It was found that the solution to the problem was to preplate the blank and perform the fabricating operations after plating. Results showed that the zinc-plating was sufficiently ductile for protection, that it had a lubricating effect, and actually increased die life.

Fig. 8 shows a redesign of several parts of the filter housing of the vacuum cleaner. The design required a crossbar to protect the louver doors covering the hose opening. The parts on the right show the original design. The crossbar was a separate piece. The filter housing had its edge rolled over, leaving two spots for clinching the bar in place after polishing and plating operations were completed. This clinching operation gave considerable punishment to the nickel and chrome plating, and frequently caused rejects due to peeling or cracking of the plated surface at this severe bend.

The louver frame has always been made from the salvaged center of another part of the unit. It contained sufficient material to make a new design of louver frame which combined the protection bar in one piece, with only one added press operation on the louver frame, and the elimination of two operations on the old bar and two operations on the filter housing and filter-housing assembly itself. The sequence of operations is shown in the illustration.

At the bottom of Fig. 8 is shown several of the operations on the louver doors themselves. Originally, they were made singly, but they are now being blanked and drawn in a double die, making right and left parts at the same operation. Bending the ears and cutting apart is combined in one operation. The right and left louver piercing dies are mounted together on one die shoe, giving a pair of rights and lefts with the same handling and in complete production balance.

The development of the bent hose end of the vacuum cleaner is well illustrated in Fig. 9. This is made from a piece of steel tubing approximately 1 ft long. At the left of the illustration are shown tube lengths as received in the press department, and the finished prewar design of hose end, including the accessory parts, an inside ferrule, a steel ring, and a brass sleeve which are combined into one insert for assembling the hose to the hose end. It will be noted that the tube itself is expanded and curled over to make a recessed lip for holding a retaining device which is not shown.

With the prewar quality of tubing and ability to maintain

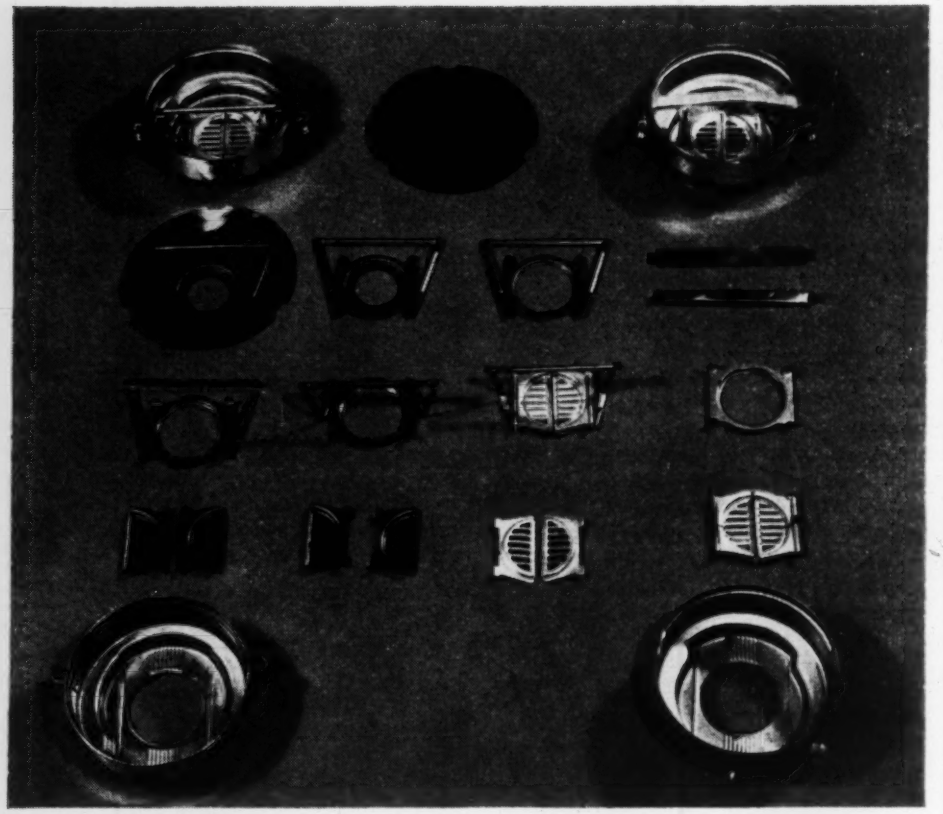

FIG. 8 ORIGINAL AND REDESIGNED FILTER-HOUSING PARTS

stocks large enough to reject and return shipments with poor drawing quality, rejects due to splits at the welded seam averaged from 6 to 8 per cent. With postwar scarcities and the necessity for purchasing tubing from any source whatever to maintain production, including warehouse lots, the losses from splitting often reached 40 to 50 per cent, owing to the extreme stretching of the material required in making the curled-over lip. This intensified the shortage and, obviously, could not be allowed to continue. Out of this necessity for action resulted the two-piece construction for the tube shown second to the left in Fig. 9. By making a separate ferrule to take care of the reverse curled lip, and only flanging the main tube sufficiently to retain this ferrule, rejects even for the less uniform miscellaneous postwar material dropped to between 4 and 5 per cent, which was less than the prewar average.

The new short-lip tube caused suggestions for eliminating some of the numerous parts of the accessory pieces, and the next series shows a combination of the new ferrule with the steel ring and brass sleeve, replacing with one piece and one press operation three pieces requiring six operations. This was accomplished by reversing the location of the retaining device.

One other difficulty and one additional accessory remained, the inside ferrule. Variations in diameter in postwar tubing caused increasing difficulty in retaining the assembly dimensions between the end of the tube and the ferrule after pressing in position, because of the multiplying effect of a small variation in diameter on the longitudinal relation of tapered parts.

Since the revised design already accomplished had resulted in less distortion of the tubing, and reduced the load on the tools required for the purpose, it was found possible to change the shape of the tube itself to provide the internal shoulder for which the ferrule had previously been required. By maintaining the correct dimensions on the punch and die rings, this dimension could now be controlled accurately without danger of splitting or excessive tool upkeep. Actually, rejects from splits now average less than 2 per cent, and some of these can be salvaged.

This sequence, therefore, resulted in reducing the number of parts from 5 to 2, with a better and more uniform quality resulting. It is doubtful whether this development could have been made in any other than the "hard way" outlined. It is interesting to note that the various suggestions for changes came from a number of different individuals and were not the result of a progression of ideas in the mind of a single individual.

In addition to the saving of material by the elimination of certain of the ferrule parts, the finished product requires approximately $\frac{1}{2}$ in. less of the scarce steel tubing, which has been a real factor in our calculation of costs.

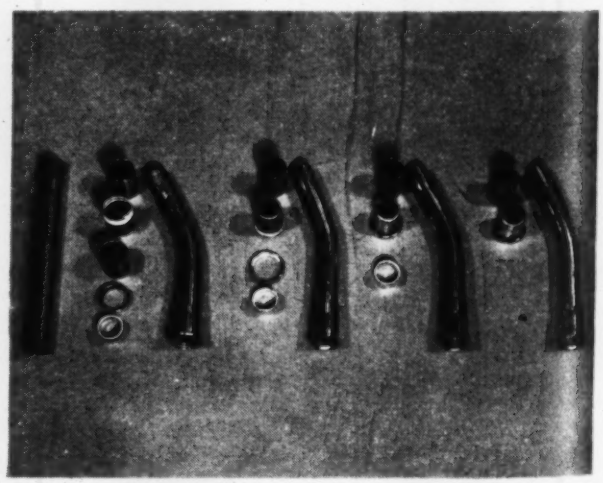

FIG. 9 DEVELOPMENT OF BENT HOSE END

The SOUTH AFRICAN RAILWAYS

A Mechanical Engineer's Viewpoint

By M. M. LOUBSER

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THE Union of South Africa is slightly over 470,000 square miles in area. South-West Africa, whose railways are administered by the South African Railways as an integral part (except for certain accounting formalities) covers slightly over 300,000 square miles, giving a total of just under 800,000 square miles, or slightly more than one quarter of the area of the United States of America. The two measure about 1000 miles east to west and 750 miles north to south, except for the South-West Africa extension to the north.

As we go inland the land rises, more rapidly in the east than in the west, forming an inland plateau varying from 3000 to 6000 ft, with a maximum of 11,000 ft; the highest point on the railways is actually 6871 ft. While there are extended inland plains at about the 5000-ft mark, the country generally is of a broken mountainous nature making railroading difficult, and the lines are often of a switchback nature. The climate on the whole is dry; the rainfall varies from under 5 in. per year to about 35 in., with only small areas getting up to 50 in. a year. The evaporation is high. There are very few, if any, rivers which flow all the year round. Water is scarce and very often of a bad quality for boiler purposes. The difference between day and night temperatures, especially on the higher inland plains, is remarkable.

The population is slightly over 10,000,000 for the Union of South Africa, of which 2,300,000 are Europeans and the rest Bantu or colored. (This distinction is not made from a racial standpoint but rather from a railway economical one, as formerly the Bantu was mainly resident in rural areas and self-contained reserves and was of little moment for the Railways; in recent years, with the development of industry and mining, there has been a decided change and a large number of passengers come from this section; also indirectly they begin to count.) South-West Africa has about 33,000 whites and 300,000 colored. Generally, the population of South Africa has doubled since 1904.

Thus, South Africa is a dry, sparsely populated country; the little population there is being unevenly distributed according to rainfall and, more recently, also according to certain mining and industrial developments.

The Cape was discovered in 1488; the first European settlement took place in 1652 under Johann van Riebeeck, who had instructions to plant vegetables and trade meat from the Hottentots to supply the ships of the Dutch East India Company. All transport was by ox wagon and cape cart until 1860, when the first 2 miles of railway were built from Point to Durban. In 1862, the line from Cape Town was opened and reached Wellington (a distance of 45 miles) in 1863. This line was 4 ft 8½ in. gage. When the Government took over the railways in 1873, there had not been much progress. In view of the geographical and financial difficulties, it was decided to change the gage to 3 ft 6 in. Fortunately, the moving structure gage, which was approximately equal to that of Great Britain, was retained so that a height of 13 ft and a width of 10 ft diminishing to 8 ft 4 in. at platform height is available. Although it could be greater to advantage, it is reasonable relative to the gage.

Diamonds had been discovered at Kimberley in 1867, and in 1884, gold was discovered at Johannesburg. Therefore, the railway lines were pushed on both from Cape Town and Durban; for political reasons and because it was the shorter route to the sea, the Transvaal encouraged a line from Lourenco Marques by a Dutch Company. It was a close race which gave Johannesburg three roads to the sea by 1895. The lengths were 1000, 500, and 350 miles, respectively. Most of the lines had rail weights of 60 lb or less, permitting an axle load of about 12 tons.

In 1910, when the four provinces united, there were 6831 route-miles of railways, with an annual revenue of £14,000,000; today we have double the mileage and an annual revenue of very nearly £75,000,000. The total capital investment is about £200,000,000 in railways proper and another £30,000,000 in harbors, and other facilities. The staff employed is 93,000 Europeans and 78,000 non-Europeans, i.e., 12 per cent and 4 per cent, respectively, of the total populations earn a living on the railways, apart from those doing so indirectly. The railways pay a "dividend" of about £6,000,000 or 3 per cent annually.

The Act of Union lays down the following edict:

"The railways, ports, and harbours of the Union shall be administered on business principles due regard being had to agricultural and industrial development within the Union, and promotion, by means of cheap transport, of the settlement of an agricultural and industrial population in the inland portions of all portions of the Union. So far as may be, the total earnings shall be not more than are sufficient to meet the necessary outlays for working maintenance, betterment, depreciation, and the payment of interest due on capital not being capital contributed out of railway or harbour revenue and not including any sums payable out of the consolidated "Revenue Fund" in accordance with the provision of sections 130 and 131...."

The "dividend" is therefore a compulsory one.

TRACK

Originally the track consisted of 60-lb rails or lighter permitting of 12½ tons axle load. Later 78 to 80-lb rails with an axle load of 16 tons were introduced. In 1910, 75 per cent was 60 lb or lighter; today 54 per cent is 60 lb or lighter, 28 per cent is 75 to 85 lb, and 18 per cent is 96 lb. Axle loads of 13 to 15 tons are allowed on 60-lb rails, 18 to 21 tons on 80 to 81-lb rails, and 22 tons on 96-lb rails; the latter is Class I line, has 2376 sleepers and 2200 cu yd of broken-stone ballast per mile, and a maximum speed of 60 mph is permitted.

The lines were originally built with a ruling gradient of 1 in 40, and even 1 in 30, with curves up to 19 deg uncompensated. Huge sums have since been expended to improve the lines, but even so, only 275 miles have a ruling gradient of 1 in 100. The best that can be achieved on the other improved sections is 1 in 80, 1 in 66, and 1 in 50, while some of the 1 in 40, and 1 in 30 is still being operated. An even bigger effort has been made to cut out sharp curves, but this also is only possible to a limited

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extent, and locomotives are still designed to negotiate a curve of 275 ft radius. The superelevation varies with the radius, and the average speeds expected; on the sharpest curves it is between 4 and 5 in.

Bridges are gradually being strengthened as traffic develops, and the class of line must be improved. New main-line bridges are designed for 22 ton (50,000 lb) axle loads, and branch-line bridges for 15 tons (33,600 lb). (While train loads are given in short tons, axle loads and locomotive weights are always given in long tons.)

ROLLING STOCK

The rolling stock consists of 2350 steam locomotives, 190 electric locomotives (designed for multiple working), 5000 coaches (passenger cars), and 65,000 trucks (freight cars).

Coaches. Originally the coaches were of the side-door suburban type about 30 ft long. The ticket examiner had to walk on the step boards from one compartment to another. Gradually the coaches became longer and the corridor type was introduced; the corridor runs along the side and the compartments are closed off by sliding doors. The arrangement is such that the seats can be converted to sleeping bunks over each other against the partitions; four in the first and six in the second class. Half-compartments, or coupés, are also provided. All are fitted with a wash basin, and common lavatories are provided one at each end of the coach. This general principle has been retained till today, although many improvements have been made. Today, the modern coaches are 63 or 65 ft long and weigh 40 tons. Bedding is obtainable at 3/6 per journey. Formerly the trains stopped at certain points for a quick meal; today most long-distance trains have a dining car serving meals at 8/6 a day.

The original coaches were of timber with steel underframes, and this practice has been retained. Teak is the timber used predominantly, and the steel used for the underframe has a tensile of 28 to 33 long tons per sq in. Such coaches have a life of 40 years. The end door frame of the vestibule is now made of channel iron instead of timber, and this provides greater safety against telescoping, as has been proved in recent collisions.

Several years ago a number of coaches with steel bodies were given a trial. They were not well insulated and are too hot in summer and too cold in winter; in addition they drummed. They showed early corrosion and were not a success. The air-conditioned vehicles of the "Blue Train," a luxury express, was the next attempt at steel coaches. They weigh over 50 tons each and are much more expensive than the standard timber coaches. The recent suburban motor coaches are also of steel. In addition a number of main-line steel coaches without air conditioning are on order.

Originally all rolling stock had a central buffer of the bell type coupled by links and pins. Several years ago, it was decided to use the automatic coupler, and this is now standard. Until such time as those vehicles which have bell buffers and are not suitable for conversion to couplers are scrapped, all knuckles must have a slot for the link and a hole for the pin to permit of their being coupled to a bell buffer. It is hoped that this transition stage will soon be over.

Locomotives. Originally the locomotives were mostly of the side-tank type. It was not long before the heavy gradients made the eight-coupled type essential; even a ten-coupled type was tried but, due probably to some mistake in design, it was not successful and one coupled axle was removed.

When, however, in 1910, D. A. Hendrie became chief mechanical engineer of the newly formed South African Railways, he started in real earnest and developed the 4-6-2 and 4-8-2 types through various stages until he reached the prototypes of our present standards. General characteristics are as follows:

Class 15:	
Wheel arrangement	4–8–2
Coupled wheel diameter	4 ft 9 in.
Axle load	16½ tons
Grate area (hand-fired)	40 sq ft
Boiler pressure	190 psi
Tractive force	33000 lb

Class 16:	
Wheel arrangement	4–6–2
Coupled wheel diameter	5 ft
Axle load	18 tons
Grate area	37 sq ft
Boiler pressure	185 psi
Tractive force	30000 lb

His efforts at getting powerful locomotives on the 3-ft 6-in. gage were greatly assisted by the introduction of superheated steam.

These two types were improved in subsequent orders until today we have locomotives with the following main particulars:

Class 15-F:	
Coupled wheel diameter	5 ft
Axle load	18½ tons
Grate area (mechanical stoker)	63 sq ft
Boiler pressure	210 psi
Tractive force	42300 lb

Class 16-E:	
Coupled wheel diameter	6 ft
Axle load	20 tons
Grate area (hand-fired)	63 sq ft
Boiler pressure	210 psi
Tractive force	35000 lb

Class 23 is similar to Class 15-F, having a driving-wheel diameter of 5 ft 3 in., a boiler pressure of 225 psi, and a bigger tender with six-wheel bogies.

More and more the trend has been to have general-utility locomotives, and the Class 15-Fes and 23 are now so used, handling freight and passenger expresses equally well. The Class 16 series is generally relegated to passenger trains of lesser importance. Class 16-E is interesting as it represents more or less a limit in that the boiler of 6 ft 2¼ in. inside barrel diam with its center line 9 ft 3 in. above rail level leaves only a few inches for the stack, and the coupled wheels in turn just clear the boiler belly.

Mr. Hendrie also designed several types of Mallets; while they served a useful purpose they were not considered too successful, probably the bad water, combined with a long boiler, was one of the reasons. Ultimately, they were abandoned in favor of Garratts, and the last of them is due for scrapping.

His successor, Mr. F. R. Collins, was responsible for introducing an appreciable number of Garratts. They were a mixed blessing but certainly had a short simple boiler with deep firebox. They could handle bigger loads than the consolidated types and helped to handle increased traffic without laying a heavier track. Various types were ordered, the double six-coupled predominating. They are expensive to maintain and therefore preference should be given to the double eight-coupled so as to get the biggest advantage for the additional complications.

The latest types are:

Class G.M.:	
Wheel arrangement	2–8–2 + 2–8–4
Coupled wheel diameter	4 ft 6 in.
Axle load	15 tons
Grate area (mechanically fired)	64 sq ft
Boiler pressure	200 psi
Tractive force	60,700 lb

Class G.E.A.:	
Wheel arrangement	4-8-2 + 2-8-4
Coupled wheel diameter	4 ft
Axle load	15 tons
Grate area (hand fired)	51.3 sq ft
Boiler pressure	200 psi
Tractive force	55,600 lb.

These will probably survive for a long time; so far, the Class G.M. has been comparatively cheap in maintenance.

Perhaps I should mention Class G.L. as the most powerful locomotive on the 3-ft 6-in. gage; probably also the heaviest built in Europe until the class 23 was built, which, with tender, actually weights 218 tons in full working order. It was used between Durban and Cato Ridge, a distance of 45 miles with practically a constant gradient of 1 in 56, before this section was electrified. To protect the crew from the terrific heat in the tunnels, it ran chimney trailing.

Class G.L.:	
Wheel arrangement	4-8-2 + 2-8-4
Coupled wheel diameter	4 ft
Axle load	18 tons
Grate area (mechanically fired)	75 sq ft
Tractive force	78,600 lb
Boiler pressure	200 psi
Total weight	211 tons

ELECTRIFICATION

The main line from Durban to Volksrust (a distance of 321 miles) is electrified. This line carries heavy traffic and rises to 5400 ft in that distance, but the total climb is almost double that figure. The first section was electrified in 1925. The connecting line to the Free State (another 60 miles) has also been electrified as the gradient up the van Reenen Pass is 1 in 30. The lightning conditions are extremely severe.

Direct current at 3000 volts is used; the supply is distributed at 88 kv ac and transformed by rotary transformers in the older substations, and mercury-arc rectifiers in the newer ones.

The locomotives have two four-wheeled bogies coupled direct so that the tractive force is not transmitted through the body. Each axle is driven by a 300-hp nose-suspended motor with single gear reduction. The tractive force (1-hr rating) is 21,200 lb, and the maximum pull at starting about 31,000 lb. The maximum permissible speed is 45 mph. Locomotives are arranged for regenerative braking. Generally a load of 1650 tons is taken by three locomotives working in multiple with one crew.

The suburban services at the Cape and on the Reef are worked by electric motor coaches. Unfortunately, the voltage at the Cape is only 1500 and will have to be changed to 3000 now that it is proposed to electrify the main line between Cape Town and Touws River. For the freight and certain other trains on the Reef, 28 new locomotives with two six-wheeled bogies have been ordered. The first few locomotives are already in service; they are rated at 2500 hp, are nonregenerative, and have a maximum speed of 60 mph.

BLUE TRAIN

The "Blue Train" consists of 12 air-conditioned coaches, total weight about 625 tons with a dynamo drag of 270 hp. Except for a banker up the 20 miles of 1 in 40 uncompensated on the Hex River Pass, this train is handled by single locomotives all the way from Cape Town to Johannesburg. The distance is 956 miles and the total time taken from start to finish is 26 hr 40 min. On the first 400 miles alone the total rise is 11,419 ft and total fall 7259 ft. The average over-all speed, including stops, is 36 mph, and 60 mph is never exceeded. In the other direction the over-all time is 26 hr 8 min, and the over-all speed is 36.7 mph.

WORKSHOPS

To maintain the rolling stock and supply other services the railways in South Africa had to have repair shops attached to the locomotive sheds (roundhouses), but at an early stage separate self-contained workshops were built. There was no industry to speak of, and the railways had to be self-reliant. Spares took a long time to arrive after being ordered and manufacture of parts started at an early stage. Well-equipped machine shops, foundries, blacksmith shops, sawmills, etc., had to be provided. For a long time the railway workshops were the biggest and best-equipped general workshops in South Africa, and probably still are. They are prepared to tackle almost anything from silver-plating a teapot to repairing a battleship.

Gradually, building of rolling stock has been undertaken, and, today, there are regular programs for building trucks (freight cars), coaches (passenger cars), and spare boilers. Recently, a start has even been made with a small number of locomotives. The costs are competitive with those of the imported articles.

Rolled sections are now predominantly obtained from ISCOR (the local steelworks) but tires, axles, friction draw gear and similar items still have to be imported; so are machine tools and most of the tool steel.

From time to time, the workshops have been extended and renovated and one or two new ones added, but at present they are definitely out of date and too small to cope with the work required. Several are to be replaced completely by new and enlarged workshops; others are to be renovated radically. The total work is estimated to cost about £18,000,000 and will take years, but it is hoped that certain blocks will be available by 1950.

CONTROL OF ROLLING-STOCK MAINTENANCE

The railways are divided into nine systems, each supervised by a system manager directly responsible to the general manager. He is assisted, among others, by a system engineer and a locomotive superintendent. The former is responsible for maintenance of track, buildings, and the like; the latter is in charge of the engineers and firemen, and the maintenance of the locomotives and rolling stock. While he reports to the system manager and is controlled by him, the chief mechanical engineer can instruct him through the system manager in regard to the technical details of his duties. The section of the chief mechanical engineer's office dealing mainly with this work is under the assistant chief mechanical engineer (motive power).

Each of the eight workshops is controlled by a mechanical engineer, who is responsible directly to the chief mechanical engineer who has an assistant chief mechanical engineer (work shops) to deal with this section. The chief mechanical engineer, as head of the mechanical department, reports directly to the general manager.

The total shop staff numbers about 14,000; they can be divided almost equally into artisans, semiskilled, and laborers, apart from the small section of supervisory and clerical staff. All artisans have to serve a 5-year apprenticeship; from their ranks are drawn the supervisors up to the rank of foremen and even works managers, as well as draftsmen. The latter must have the Advanced Technical Certificate II, as obtained by successfully attending day and evening classes at the technical colleges during the period of apprenticeship, or even thereafter.

The semiskilled, or operatives, are trained and promoted from railworkers (i.e., European laborers) or "lads" (i.e., junior trainees). The laborers are either European or non-European (colored, Indian, or Bantu).

Formerly, the engineers were selected from promising artisans or "premium" apprentices, who had shown promise in the

drawing offices. In more recent years, young men who have their B.Sc. (Engrg.) degree also have been taken on as pupils and promoted to assistant engineers after 3 years of training both in the shops and the motive power side, i.e., with the artisans in the shops and the running sheds, with the engineers on the footplate, in the drawing offices, and with the assistant engineers. More and more this method of recruiting engineers seems to become a matter of policy.

The engineers start as learner firemen, then become firemen (stokers) and, after passing certain prescribed examinations and having been firemen for at least 5 years, they are promoted to driver (engineer). There are various grades, and in addition a driver can be promoted to running-shed foreman and locomotive inspector.

The running maintenance of the locomotives is undertaken in the locomotive sheds (roundhouses). Washouts and boiler repairs are done by artisan boilermakers assisted by operatives; the mechanical repairs are done by fitters. The locomotive foreman generally is promoted from the ranks of the fitters. He is assisted by one or more running-shed foremen, who are responsible for booking out the drivers and locomotives.

If there are delays which are due to the locomotive or driver, it is classed as a locomotive delay; if more than 15 min is lost, the driver gets a docket and has to explain in writing. If the locomotive fails to complete the journey on the train owing to defects, it is a locomotive failure. Due to various causes, which can possibly be ascribed to the war and its aftermath, locomotive delays and failures have increased, and mechanical officers are at present giving special attention to this aspect.

Lubrication of rolling stock generally, including the carrying wheels on locomotives and tenders, is by means of oil-soaked wool waste; coupled wheels and side rods are lubricated by hard grease, and this lubrication has been very successful. On the carrying wheels and tenders, heating has been rather high and, in recent years, roller bearings have been fitted. This is also true on passenger cars. Such bearings are not an unmixed blessing as they also heat up. When they do, the results are rather devastating as they then require not only a new bearing but very often a new axle as well. Therefore, replacements are expensive and, as the roller bearings are not made in the country, difficulties occur due to shortage of supplies.

SPECIAL ASPECTS (LOCOMOTIVE DESIGN)

From the foregoing, it will be clear that the first consideration in locomotive design was high tractive force to negotiate the heavy gradients. As axle loads were restricted (even today they are low from an American viewpoint) and sharp curves were and still are plentiful, it will be understood why there was a tendency to use small coupled wheels and have at least eight of them; where this did not suffice ten coupled wheels were tried, but it was difficult to find suitable designs and Mallets and later Garratts had to be used, notwithstanding the additional complications. As higher speeds are demanded the tendency now is to make the coupled wheels as big as circumstances will allow to reduce wear.

The sideplay between a standard new wheelset and the track is $^3/_8$ in. On curves up to 700 ft radius a gage widening of $^3/_4$ in. is allowed; from 700 to 1000 ft it is $^1/_2$ in.; from 1000 to 1500 ft it is $^1/_4$ in. These values must be added to the $^3/_8$ in. to get the total sideplay. Check rails on curves and crossings are so arranged that the check rail touches the inside of the wheel at the same time as the flange of the opposite wheel is hard against the other rail; all wheelsets have the same dimension of 3 ft 3 in. between tires.

Various methods were used formerly to get an oversight of how any given wheel arrangement would negotiate the various curves. The classical one was the Roy method. This method is, however, an approximation and with our long wheel bases and sharp curves the possible error is very appreciable and the method becomes unreliable and therefore useless.

The elliptical method has therefore been adopted as standard. According to the principles of analytical geometry the circle is reduced to an ellipse. At right angles to the engine the reduction is to half or quarter full size and parallel to the engine to $^1/_{24}$ or $^1/_{40}$ full size. We therefore get the displacements half or quarter natural size and engine length $^1/_{24}$ or $^1/_{40}$ full size and can work on a normal drawing sheet or a folio size, respectively.

The two rails are represented by two lines (ellipses) situated apart by an amount equal to $^3/_8$ in. plus the gage widening (to the correct scale) and the locomotive by a single straight line with specially marked points for the wheels. The various possibilities can then be seen at once graphically.

The ellipses are calculated and drawn once for all for different radii and by putting tracing paper over these curves such an investigation can be completed in a few minutes. The method is exceedingly accurate and most useful. Turnouts and similar special pieces of track can be plotted and investigated in the same way.

While originally tractive force was the main consideration the general demand for more speed has not gone past South Africa. The maximum speed is limited by several factors with the present absolute maximum of 60 mph. Time can, therefore, only be reduced for the over-all journey by increasing the speed on the slow sections, i.e., eliminate the sharp curves and increase the speeds up the banks.

The present basis of design is therefore:

(*a*) Eight coupled wheels as the most that will give a reasonable arrangement for the sharp curves, bearing in mind that the wheels should be as large as reasonably possible to give high maximum speed and minimize wear and maintenance.

(*b*) The maximum axle load and adhesive weight that the track will allow.

(*c*) Cylinder dimensions that will give a tractive force, calculated at 75 per cent of the boiler pressure, equivalent to at least one quarter of the adhesive weight; generally a figure of 1:3.8 or even slightly more is adopted.

(*d*) All the available carrying capacity left is used to put in the biggest boiler possible, the main stress being on size of grate area, according to Lawford Fry's theory, with reasonable proportions to correspond.

(*e*) Spark arresters of the "Master Mechanics" self-cleaning type are fitted. As the result of recent experiments we believe to be able to prescribe the size of the cross sections at the various stages in terms of the tube area.

(*f*) Unless special considerations determine otherwise, a mechanical stoker is fitted to grates of 60 sq ft and over.

TESTS

Since 1927 the South African Railways have had a dynamometer car (ex USA) and regular tests were carried out till the outbreak of war. Much work has been done to get the correct proportions for the front end but details would take too much time. For ascertaining locomotive performance and efficiency the procedure is briefly as follows: Coal is weighed in bags, samples being taken to determine calorific values; the tender is calibrated by means of a glass tube and calibrated scale, one on each side of the middle of the tender. The boiler gage glass is calibrated by feeding from the calibrated tender while standing and reading the amount of water for every inch. The coal and water consumed can therefore be determined from watering station to watering station.

The boiler performance is kept steady for each test in so far as possible by working to a predetermined back pressure measured in the exhaust pipe well below the nozzle, it being accepted

that if the back pressure is kept constant so will the draft and firing rate be. This is the nearest approach to working at a constant rate than can be achieved in track tests. Burning rate is calculated on the steaming time (the little coal burned while drifting being neglected).

The drawbar horsepower-hours are determined by the integrator on the car. While indicator diagrams are usually taken, the ratio between indicated and drawbar horsepower is not constant on track tests and attempts to calculate the indicated horsepower hours are therefore not too successful. Moreover, the evaluation of indicator diagrams is a laborious work. A useful unit that is regularly used has been introduced, viz, "effective horsepower-hour." It is obtained from the drawbar horsepower-hour by increasing it in the ratio, weight of train and locomotive to weight of train. It will be seen that this unit corresponds more or less to brake horsepower of a stationary engine, or, in other words, it is the work that would be done at the rims of the driving wheels if the engine were jacked up; it is slightly nearer to indicated horsepower-hour than the drawbar horsepower-hour as obtained in the Altoona test plant.

This unit is a good one for comparison of the performance of locomotives being independent of the ratio of the weight of the train to that of the locomotive. It has also been found that the value of the effective horsepower-hours used per ton total weight is very nearly constant for all trains between two given points. Having determined this figure and knowing the basic consumption figures for a given locomotive, the coal and water consumption for any assumed load can be calculated at once. The practical application of this method is obvious.

The track tests results are usually plotted with firing rate in pounds per square foot of grate area per hour as a basis and in this way the consumption and various other figures relative to firing rate can be determined. While a slow heavy train or a fast light train, both to the same firing rate, is not strictly comparable, it is surprising how close the test points lie relatively to the average curve.

WATER TREATMENT

In view of the bad nature of many of the waters, it is not surprising that fairly early attempts at treatment were made. Isolated lime-soda plants were erected at the beginning of the century; in South-West Africa, the Germans had a fairly systematic lime-soda treatment, and at Beaufort West a distilling plant was erected. Most of these early attempts were abandoned in favor of internal treatment with various materials.

In 1924, a new start was made with lime-soda plants on a small scale under strict chemical supervision. Since 1930, the use of water-treatment plants has been extended. The lime-soda plants are of the Paterson type and treat water having a total hardness up to 80 parts per 100,000 (temporary 30, permanent 50). The method has been improved by "floc control" by the addition of sodium aluminate. The treated water is further conditioned by the addition of briquettes, etc.

On certain sections by-pass or wayside treatment is adopted, while on the coastal sections, where the water contains root acids, lime has to be added. Where river waters are used, clarification is necessary. In fact, the only boiler explosion known to the author was caused by feeding unclarified water after a thunderstorm.

On the Cape Midland System, a series of "Permutit" base-exchange plants was installed in 1942, with marked success. Here the water has a hardness of about 35 and is softened down to about 1-2 parts in 100,000, whereas by the lime-soda process, we soften to about 3 parts per 100,000.

It has been found that not only is boiler maintenance appreciably reduced by water treatment but longer periods can be allowed between washouts. Without antifoam, it is possible to go to a concentration of about 250 total solids in 100,000, and with antifoam to 500 parts total solids before priming commences. To prevent the concentration going above these figures, a system of continuous blowdown supplemented by blowing down by hand has been introduced.

THE "BLUE TRAIN" EN ROUTE FROM JOHANNESBURG TO CAPE TOWN

ACCIDENT PREVENTION

Using Operations-Analysis Procedures

By JOHN V. GRIMALDI

ASSOCIATION OF CASUALTY AND SURETY COMPANIES,[1] NEW YORK, N. Y.

SAFETY engineering can be an important part of scientific management because it offers a logical and systematic procedure for reducing costs, increasing production, and solving management problems. Its acceptance as an industrial necessity will continue to depend on the abilities of its practicing members, who through the application of scientific procedures and deductive thinking will develop the principles of safety from a philosophy to a science.

It was an appreciation of this need which motivated us to try the application of methods-engineering procedures to certain selected accident-prevention problems. Fundamentally, the methods engineer makes a contribution to management similar in scope to the safety engineer's. The safety specialist is concerned with the harmful influence of faulty operations and poor design on successful production as indicated by the occurrence of accidents.

Before describing the application of operations-analysis procedure to accident-prevention work, our interpretation of the relationship between methods engineering and safety engineering as it applies here will be stated.

METHODS ENGINEERING

Methods engineering is a device which subjects each operation of a given job to close analysis in order to eliminate every unnecessary step, and thus determines the quickest and best method for performing each essential operation. The operations analysis is the first step toward obtaining all the possible facts relating to the job. It should not be confused with time and motion-study analysis, which is the secondary step in methods engineering and is made when the time required to conduct such an analysis is justified. For our purpose, time and motion-study analysis is outside the realm of safety engineering.

Since the objective of the operations analysis is to determine the details of a job, it should be the principal tool of the safety engineer, for the following reasons: (1) He must know the details of a job before he can make a sensible corrective recommendation. (2) Since the ultimate purpose of the procedure is to reduce unnecessary steps, this reduction in itself will lessen the degree of hazard. This is of paramount importance for the accident preventionist should be accepted not only as an eliminator of hazards but also as an improver of industrial productivity through increased mechanical and personnel efficiency.

In order to give the procedure a name suitable for our purposes, we call it, "methods safety analysis." As the term implies, it is primarily concerned with investigating the mechanical hazards of the methods of an operation, rather than determining its hazardousness due to various personal factors of the workers. Offhand, one may think this is an incorrect approach to the business of eliminating accidents, for we know that the worker is most often responsible for accidents through his personal failure. However, the causes of his failure, it must be remembered, are influenced by his mental or physical make-up, according to his inherent characteristics, e.g., he either has naturally quick reflexes or he does not; he is intelligent and has the correct attitudes for safety, or he does not; he may fatigue easily, or be highly excitable, and so forth, depending on the person he is. Such qualities or the lack of them are difficult to determine without psychological or psychiatric testing and are therefore beyond the scope of the methods safety analysis. Occasionally, however, these characteristics are affected by certain materials and conditions which are definite parts of the methods of a job. For example, such materials as carbon tetrachloride, methyl chloride, trichlorethylene, and carbon monoxide can cause dullness, confusion, excitement, and languor, headache or visual disturbances, plus other effects directly responsible for accidental injury. Unpleasant working conditions such as poor lighting and noise, may have a similar effect.

Since accidents often can be attributable to human defects, rather than to mechanical, the safety engineer must know, concerning any accident, how much of the responsibility for its occurrence can be placed on human defects and how much on mechanical. Only then will he be certain of what preventive measures should be used and where they ought to be emphasized.

PERSONAL FACTOR IN ACCIDENTS

Even though the methods safety analysis like all other accident-investigation techniques is unable to point out explicitly the personal accident factors, it does assist in determining how accountable the personal factors are. This is possible by being able to investigate the mechanical and methods hazards more closely. The investigator can ascertain, therefore, how much of the responsibility lies with the methods of a job. If the operations of a job are found to be well planned, with no particular chance for accident, then the reason for the occurrence of an accident must be due to personal factors.

The fundamentals of the methods analysis for safety are the same as for any operations analysis. They are as follows:

1 Break down the job or operation into its elementary steps.
2 List them in their proper order.
3 Then examine them critically.

The only difference is that while the operations analyst investigates the steps of a job with the aim of eliminating those that are unnecessary, or substituting for those that are inefficient, the safety engineer examines each step for its possibility of causing an accident. Sometimes he achieves the same results as the operations analyst who is principally concerned with the efficiency of the job, for the safety analyst will find the opportunity to eliminate hazardous steps rather than guard them. At other times, he may be able to reduce the number of steps as

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a whole and thereby decrease the hazardous aspects of an operation, for the fewer the steps to be performed the less will be the exposure to accidents for any one cycle of an operation.

There are four units to be considered when analyzing a job operation for its possible hazards; these are as follows:

1 Man: A representative word including one or all of the following: The operator, the supervisor, any other person or individuals responsible for safety on the job, the injured person,

2 Method: The working procedures of the process being investigated.

3 Machine: The machine tools employed; there may be one or more.

4 Material: The substances and articles, other than machine tools, employed in the process.

"Man" is generally the unit it is desirable to protect from accidental injury caused by faults in the other three units of the group. Therefore the investigator is concerned first with the potential hazards to personnel, involving the method, machine, or material. We can consider that the major types of accidents on the job, which are apt to be caused by these three remaining quantities, can be placed in eight groups as follows:

(*a*) Fall of person—on the same level.
(*b*) Fall of person—from one level to another.
(*c*) Overexertion—causing strains.
(*d*) Falling, sliding, flying objects.
(*e*) Caught in, on, or between.
(*f*) Struck against.
(*g*) Temperature extremes and electric shock.
(*h*) Inhalation, absorption, swallowing.

MAKING THE ANALYSIS

The success of the analysis depends upon the attitude of the investigator. As a matter of routine, he can merely list the steps of the operation and enter his observations on a chart, in which case he will learn more of course than if he never made the survey at all. Or he can adopt for himself a questioning attitude as he lists each step which will compel him to inquire about the reaso for each step's being performed and for the use of the procedure that is being employed. It is only by questioning and investigating that he can learn the facts concerning the operation as it is presently being worked, and he can then make a prudent decision as to what should be done to safeguard it and maintain or improve its productivity. He should remember that operation procedures can be improved time and again as engineering ingenuity and a fresh viewpoint are permitted to influence the subject. There should be no hesitancy to ask questions on the part of the analyst for that is the scientific way if onvestigating any problem. The scientist refuses to accept as gospel that with which he is unfamiliar. He recognizes that it is no disgrace to be ignorant of an unfamiliar subject, but it is not to his credit to neglect to acquire knowledge when necessary. He accepts little or nothing as being right because it exists, but asks questions. Quite often it is a decided advantage to ask questions even when the answer is apparent, for thinking is thereby stimulated and new viewpoints and ideas are contributed.

Similar to operations analysis, the methods safety analyst examines each step of the job or process from its very beginning, which usually is the issuance of the work order, job ticket, or blueprint. As each step takes place in the operation of the job or process, he notates it by numbering it in its proper order, followed by a brief description of the step. To facilitate the methods-analysis procedure, it is recommended that the investigator provide himself with a clipboard, several prepared outline sheets of paper of standard letter size, and a few well-sharpened pencils so that he can make notes readily and legibly.

Then he examines the step with respect to the method, machine, or material involved to see if any or all of these three can be responsible for the cause of one or more accidents of the types just listed. If he finds a step that is potentially hazardous he notates (alongside of the step description) the alphabetical letter representing the type of accident apt to be caused. He has a record, therefore, of (1) the steps of the job, (2) those steps which might be hazardous, and (3) a means of reference for additional study of these steps, if necessary, in order to apply the proper corrective.

TYPICAL EXAMPLES

Case 1: Two employees in an inspection department, at separate times, had received smashed toes when a stack of 30 pieces of armor plate, approximately 36 × 24 × 3/8 in., standing on end against a workbench, lost its support and slid to the floor. It was reported the pieces of armor plate were stacked on end because the department was crowded and there was not sufficient room to leave them on the skid pallet on which they were delivered. (The pallet containing the armor plate had been towed from the receiving department to the inspection crib, a distance of approximately 50 ft.). The pallet was approximately 6 × 4 ft in size. Inasmuch as each piece had to be Rockwell tested, the men piled the pieces on end as they removed them from the pallet. This was apparently easier than finding space to place them flat on the floor, then later lifting them to the Rockwell machine workbench. The foreman's report showed that similar accidents had happened several times but only in these two instances had an injury occurred.

After the usual accident investigation, it was recommended that men working in this inspection crib wear safety-toe shoes, and the hazard was believed to be eliminated. When the accident was analyzed according to the methods safety analysis, a

TABLE 1 COMPARISON OF OLD AND NEW METHODS OF HANDLING ARMOR PLATE

	Old method		New method	
Step	Description	Accident possibility	Description	Accident possibility
1	Armor plate delivered (30 pcs/day) on pallet from component plant	D	Armor plate delivered on steel table	
2	Hydraulic lift picks up pallet		Tow to inspection department	
3	Tow lift to inspection department		Armor plate remains stored on table until ready for test	
4	Remove armor plate from pallet and stack against bench	C	Slide armor plate off table to Rockwell bench as needed	D
5	Armor plate remains here until worked on	D	Send table back to component plant	
6	Remove pallet			
7	Lift armor plate, piece at a time, to Rockwell table	C		

RECOMMENDATION: Provide a welded tubular steel table 40 in. × 30 in., the height of a workbench. Equip table with 6 in. casters and a wheel lock for 2 of the wheels. Make two so that one is always at component plant waiting to be loaded.

NOTE: Apparently the hazard (type D) in step 4, permitting injury to the fingers of the man who is sliding the armor plate, still exists. However, this is overcome by using a 3/4-in. × 3/4-in. × 2 ft piece of wood as a wedge placed under the armor plate as it is slid from the pile to the workbench. The wedge is pulled out when the piece of armor plate is in position and is used in the same manner for the next piece.

TABLE 2 COMPARISON OF OLD AND NEW METHODS OF PRESS OPERATION ON SMALL PARTS

	Old method		New method	
Step	Description	Accident type	Description	Accident type
1	Thread strip through bottom die		Setup die	
2	Place die under ram	E	Thread strip through bottom die	
3	Place top die in correct position over bottom die	E	Trip the treadle	
4	Press two hand controls		Thread strip through bottom die	
5	Remove dies from under ram	E		
6	Place blanked piece in receptacle			
7	Separate top die from bottom			
8	Thread strip through bottom die			
	Pieces produced—8 per min		Pieces produced—25 per min	

RECOMMENDATIONS: In order to keep added expense down to a minimum, the blanking dies can be improved by converting them to "setup" dies. This can be done by adding 3/4-in. plates to the backs of the top and bottom dies and providing 3/4-in. dowel guide rods to maintain the fixed positions of the dies, thus permitting the bolting of the bottom die to the bed of the press and the top to the ram. This, it is emphasized, can be done using the same blanking die now employed. The area around the ram should be guarded by a barrier enclosure and the press can then be operated by a foot treadle, discarding the two-button control. In addition, the press could be inclined, permitting the cut piece to slide out the back of the bottom die, into a receptacle.

more efficient elimination of the accident-causing factors was achieved. The analysis is outlined in Table 1.

In Table 1 it will be noticed that the number of steps of the operation have been reduced from 7 to 5, and at the same time the safety conditions have been distinctly improved. The case just described is an example of the analysis of a process involving a flow of material rather than a mechanical operation. The next example concerns the investigation of a mechanical operation.

Case 2: A small shop possessing two punch presses had a subcontract to blank out and, in some cases, to form certain airplane small parts. The orders for blanked pieces far exceeded those for pieces to be formed. The number of pieces produced with each die, on a run, amounted to only 1000 to 3500, approximately, depending upon the piece. It did not pay the shop owner, therefore, to make compound dies, use an automatic feed, or other more productive, but more expensive devices on his presses when he was required to produce so few pieces. Therefore for blanking he used the drop-through type of blanking die which necessitated separation of the top and bottom dies manually after each cycle of the press. Then the operator was required to put his hands under the ram in order to place the top die in correct position relatively to the bottom die in preparation for blanking the succeeding piece. The material was fed through a slot in the bottom die in strips 4 ft long. A two-button control requiring simultaneous pressure on both buttons to operate the presses constituted the safeguard on each. Table 2 indicates the results of the methods safety analysis.

It is apparent in this case, as in Case 1, that improved safety increased the efficiency of the job, for the number of steps of operation have been reduced from 8 to 4, while the number of pieces turned out is 4 times as great.

ADVANTAGES OF METHODS SAFETY ANALYSIS

The advantages of such an investigation procedure as the methods safety analysis are many, some of which may be cited as follows

1 It maps out all the details of an operation so that they can be studied and restudied.

2 It is quick, simple, factual, and objective so that its results can be used easily and with confidence.

3 It permits a ready comparison of the undesirable method and the proposed new method, demonstrating the types of hazards and number of steps involved in each.

4 It presents a picture of the effect on production which a safety improvement will have.

5 It is an aid in showing management, when necessary, that a properly designed safety feature does not hinder productive output and, therefore, can assist in convincing management of the benefits to be gained by improving the safety of a method.

6 It permits the engineer to discern and improve ways for increasing the productivity of an operation.

7 It facilitates the analysis of the safety potential of a job before an accident has occurred

8 It assists in the thorough investigation of those methods which have involved accidents, but in which the causes are obscure.

9 Perhaps, of greatest importance, is the evidence it provides to support the safety engineer's too often disputed contention that "improving a shop's safety will increase its production efficiency."

Safety

INDUSTRIAL injuries can be reduced substantially if designers and users of material-handling equipment realize the alarming extent of accidents and economic loss caused by unsafe handling practices as reported by the National Safety Council, according to Charles S. McIntyre, vice-president, Monroe Auto Equipment Company, Monroe, Mich.

Recent Council figures show that one fourth of all compensated injuries and one fifth of all compensated permanent disabilities in eleven leading industrial states were the result of unsafe methods of moving parts and equipment.

These figures are all the more surprising when it is noted that the causes, in many cases, are so simple as to escape ordinary attention. Twelve per cent of these "unsafe methods of handling materials," for example, were caused by lifting in an awkward position and lifting with a jerk. Eleven per cent were caused by lifting with the back instead of the legs. Another 13 per cent were caused by workers having a poor hold or grip.

Here, alone, is a total of 36 per cent of the materials-handling accidents that probably could have been prevented by using equipment readily available today. Lifting with bent back and lifting in a stooping position can be avoided by using skid boxes mounted on stands to feed materials to machine operators through the bottom so that stooping over is not necessary. Poor grip can often be corrected by using pallets and other equipment with rounded edges that permit a firmer grip and also eliminate cut hands and fingers as well as damage from sharp edges to tear bags and cartons and fatigue banding wire. Pallets and boxes that are designed for easy moving about with lift or hand trucks often will remove the temptation to move it by hand or perform some other straining or awkward operation.

New materials handling equipment offered with a view to safety as well as greater production and lowered costs, includes:

A drop-bottom skid box that feeds part by gravity through a bottom that is released by a convenient lever, permitting forgings, stampings, castings, and other small parts to slide down into a convenient, waist-high tray that is readily accessible to the operator. The boxes are mounted on stands so that stooping over and bending are eliminated.

LABOR-MANAGEMENT CONFLICT OR CO-OPERATION?[1]

By PAUL PIGORS

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

FOR national welfare there can be no question as to which alternative is desirable. On the other hand, in these confusing days, it is difficult to see where we are heading. Newspaper headlines are full of strike threats in almost every major industry. Less widely publicized, but equally apparent to the careful observer, are many signs of progress.

Barbash's excellent book,[2] "Labor Unions in Action," is valuable in helping the layman to assess current events in labor relations. He gives a concise and illuminating analysis of the reasons why workers join unions and why unions must organize workers. He also provides much readable and interesting material on the structure, government, and function of unions; their basic techniques of collective bargaining and strikes, as well as their many-sided concern with civic and political affairs. Despite its brevity, the book provides a worth-while and fair-minded survey. It also contains many pages of notes and references.

The author shows that in America union activity and leadership are extremely diverse and dynamic. Both factors naturally make it difficult to generalize about unions and to reach significant conclusions.[3] Nevertheless, the book is instructive, especially the chapter on union leadership which contains many helpful observations. For example, the author makes several distinctions that provide a useful test for differentiating between union leaders as politicians and as labor statesmen. The former are chiefly interested in securing short-run gains for their membership; "more here and now." They are very conscious of their need to build and maintain a following in order to make secure their leadership status. Too much of their productive energy is dissipated by attention to details. In Barbash's opinion, the foregoing preoccupations constitute the "hard core of qualities common to all union leadership." Actually, however, this type of response is almost necessarily imposed upon labor leaders by the political character of their position. Only such outstanding men as the late Sidney Hillman, Philip Murray, David Dubinsky, and Walter Reuther, for example, have been able to free themselves from these limitations and to attain the stature of labor statesmen. Unlike politicians, who exploit the power of numbers and who act on expediency, statesmen develop policy. They act on the realization "that the union has a positive stake in maintaining and increasing the efficiency of industry (and) that the conflicts of interest between labor and management, while they exist, can be minimized by establishing, adhering to, and developing a kind of collective bargaining common law." In the words of Walter Reuther, labor statesman are not interested in operating "as a narrow economic pressure group. They want to make progress with the community and not at the expense of the community."

Many of these leaders have been able to establish sound co-operative relationships with management. However, Barbash makes the significant statement that such union-management co-operation "grows out of the economic realities of a given industrial situation. It is a vital force only where the union is strong and is accepted by management."

The book by E. J. Lever and Francis Goodell,[4] "Labor-Management Cooperation," addresses itself specifically to the problem of developing teamwork relationships. The authors redefine the problem of mutual relationship between management and labor in view of our modern technological situation. In their opinion, management and labor need no longer focus attention on vying with each other to maintain narrowly defined self-interests in an economy of scarcity. "Instead, the problem is: How can our unions now assume their share of responsibility in working best with management? How can management best utilize labor's demonstrated capacity to co-operate in a joint program for increased productivity?"

The authors advocate the Joint Production Committee as the best means of "channeling everyone's good will toward the one goal of greater production." The bulk of the book presents a detailed analysis of the mechanics of setting up and running a joint production committee. Thus it could more appropriately be called a Joint Production Committee Handbook. This is both its virtue and its defect. It gives many practical hints to those who are responsible for setting up such committees. But in describing only one solution to the broad problem of management-union co-operation, the authors have unnecessarily limited the subject. As a result, the book lacks the vitality and sweep of its British counterpart, G. S. Walpole's epoch-making book, "Management and Men."[5]

William Gomberg's challenging book,[6] "A Trade Union Analysis of Time Study," might at first glance seem to fall outside the scope of this review. It is a scientific analysis published for the Industrial Relations Center of the University of Chicago. On the other hand, two facts give it an important place here. First, Dr. Gomberg is the Director of the Management Engineering Department of the International Ladies' Garment Workers' Union. The existence of this institution in itself is convincing evidence of a progressive union's interest in scientific management. It has been instrumental in solving many knotty collective-bargaining problems which gravely concerned both workers and management. Second, and even

(*Continued on page 534*)

[1] One of a series of reviews of current economic literature affecting engineering prepared by members of the Department of Economics and Social Science, Massachusetts Institute of Technology, at the request of the Management Division of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS. Opinions expressed are those of the reviewer.

[2] "Labor Unions in Action: A Study of the Mainsprings of Unionism," by Jack Barbash, Harper & Brothers, New York, 1948, 224 pages.

[3] His difficulty receives confirmation, all the more convincing because it is unintentional. In the short time which elapsed between the preparation of the manuscript and the publication of the book, many of his statements had already been superseded by events. Cf. pp. 52, 185, 199, 209.

[4] "Labor-Management Cooperation and How to Achieve It," by E. J. Lever and Francis Goodell, Harper & Brothers, New York, N. Y., 1948, 128 pages.

[5] "Management and Men: A Study of the Theory and Practice of Joint Consultation at All Levels," by G. S. Walpole, Jonathan Cape, London, England, 1944.

[6] "A Trade Union Analysis of Time Study," by William Gomberg, Science Research Associates, Chicago, Ill., 1948, 188 pages.

SOCIAL ASPECTS *of* DECENTRALIZATION

By DON G. MITCHELL

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AMERICA has grown great by mechanization. It has developed the largest volume of power and has so increased the productivity of the individual workman that our standard of living exceeds that of any other nation. Wages are higher here, hours of work generally are less. Workers live in better houses, have more automobiles, radios, telephones—but still they are uneasy. Their discontent is evidenced by the degree of labor organization, by the number of strikes, by the repeated demands for higher wages and other benefits, by the number of radical leaders, by their political-action groups, by their desire to have more of a voice in management decisions.

Regardless of what the development of the machine has accomplished for the people of the United States, progressively, it has taken from the workers something that cannot be compensated for by more material things and more physical comforts—individuality.

That is the fine thing about the American worker—he has a sense of essential values. He realizes the importance of such fundamental things as freedom, individuality, soul. When these are gone, life itself becomes mechanical and all men puppets subject to the whims and fancies of those in control. We see this happening in many countries where the worker never did share in the good things of life as much as American workers. Nevertheless, the same doctrines of statism and communism have gained converts here.

Most people cannot understand why anyone with all that America has to offer by way of independence and plenty, and even luxury for most, could accept any authoritarian doctrine such as communism. It can only happen as labor is convinced that it has been reduced by the machine to an economic abstraction.

Battling these foreign political and social concepts by legislative enactments may produce some temporary checks, but in the long run more progress will be made by understanding and eliminating the sources of infection. This is a job in which industry by voluntary action can do more good by progressive management than government can do by regulatory legislation.

Government, especially in a democracy, doesn't cure social problems, it merely applies mass soothing syrup in the form of mandatory restrictions which leave little or no incentive for voluntary betterment. In fact, social history is full of proof that the more we leave to government in this area, the more circumscribed and regimented the individual becomes.

Democracy can go forward only when men and women are persons, not numbers. The dignity of the worker must be restored. As America was physically made great by the "Machine Age," through which we have come to our present state, so will America become socially much greater by starting now to establish the "Age of Man." Industrial decentralization is an important step in that direction.

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PRACTICAL AND ECONOMIC CONSIDERATIONS

Lest anyone gain the impression that decentralization is purely an effort to correct social problems which have arisen in industry, let him be assured that it is very realistic and practical. Neither the company with which the author is associated, nor any other manufacturer with a desire to be progressive, could afford to engage in decentralization unless it proved itself economically. Some operations, such as heavy-equipment production, demand concentration. Therefore it would not be justified economically to decentralize their manufacture. Even in this case, however, it may be that feeder plants for certain parts and operations could provide some degree of decentralization.

Any loss in the efficiency that comes with centralized coordinated production, we feel, is more than made up by the improved productivity of the employees in our smaller plants. For instance, we have found a better attendance record, less absenteeism, smaller turnover, and greater pride in the work. Spoilage is less and production errors are detected more readily.

It may not be possible always to determine these benefits from company records. There are many overlapping influences which sometimes have to be weighed before the benefits can be evaluated properly. For instance, it is not at all unlikely that wider variations in efficiency, as between two plants, can be attributed to the experience of plant managers rather than to plant location. We know this to be true in some of our plants where an older and more experienced manager of a plant no more favorably located than a plant managed by one less experienced has a better record.

Other factors which have a bearing on results are the number of changes of type of production, newness of the general product, union leadership. One cannot expect, therefore, to get a clean-cut comparison merely by isolating the factors of decentralization when so many other factors, some of which may be controlling, are present.

There are other benefits from decentralization which, though classed by some as intangibles, nevertheless are real and substantial. With the increase in divisions and subsidiaries and with a growing diversity of product, decentralization helps to break down the complexity of the task and lightens the burden on any group of executives.

Plants located closer to regional markets bring faster and better customer service.

During periods of expansion less industrialized areas frequently offer many attractive features such as lower land cost, taxes, etc.

Especially important is the opportunity that decentralization offers for experimentation, particularly in the field of industrial relations, before instituting plans, policies, and procedures on a company-wide basis. Examples are installation of job evaluation, time study, merit rating, rumor clinics, employee-attitude surveys, running plants with or without cafeterias, or broad programs of recreational activity to get a comparison.

Moreover, decentralization is not a formula that will cure all

of our social and economic problems just by taking large doses. Nor is it an unmixed blessing. It, too, has its pitfalls, and these must not be overlooked in a blind allegiance to the principle.

For instance, a popular conception of decentralization is the establishment of many factories in rather small communities. That is not the correct approach. Some limited operations may do very well in small towns, but, in general, decentralization should not be carried so far down the scale of community size that it boomerangs. A community, for instance, must not be so dependent upon a single plant that a shutdown brings suffering upon the entire population. Rather than let such a situation develop, it might be far better to help the community to secure more diversified employment, even if it means a reduced operation on the part of the single plant. If a factory is so large as to absorb nearly all the available labor, it is penalized in that it has little or no opportunity to exercise any selectivity in hiring workers, while the local people are apt to feel that they have little or no freedom in choice of employment.

Regardless of the management, when a plant becomes too large for its locality the workers know it, and realizing how dependent the company is upon them, take advantage of the situation. Under such circumstances plant efficiency naturally suffers.

In other words, it is possible for a community to be too small to justify the establishment there of a factory of the proper size for a particular operation. Since different products will have different plant sizes for economic production it is difficult to set any hard and fast rules for the ideal size of community. This we do know, however, that communities can be so small or local operations can absorb so much of the local labor that they are mutual liabilities.

Diversity of location and community selected are important but not more so than the size of plant. Herein lies the very heart of decentralization.

PROPER SIZE OF PLANT MUST BE DETERMINED

How big should a plant be to enjoy the best operation? General Robert W. Johnson, chairman of the board of Johnson & Johnson, stated the case very aptly when he said: "A factory should be as long as a man's shadow. A factory which one man can fully comprehend is just about the right size."

How many times have we heard it said of a company, which had grown big, that there wasn't the same spirit as when the "old man," who started the company, was around. He knew not only every operation, but every employee and could call him by name. No matter how rough or gruff he may have been, he was as a rule greatly respected. He may have been a martinet but his employees were people, not mere numbers.

In some ways, I like to think of decentralization as a return of the "old man" to production. Each plant, in other words, should be of such a size that one man could know everything that is happening at each bench, know every machine operation and, equally important, know all the employees. Under these conditions, the plant manager is boss. He operates that plant and makes decisions, within of course the company's basic policies, as though it belonged to him.

With such a program of decentralization, the broad policies can be worked out by and come under the control of top management, after which the executive direction of the company will be more advisory and consultive than directive. Plant managers will be expected to make their own decisions and to be responsible for results. There is little room for alibis where there is undivided authority.

When expressed simply it sounds easy but as a matter of fact greater attention to organization duties and responsibilities is necessary in a decentralized operation, because the channels of communication between individuals are not as simple. Just the mere physical separation of many miles makes it more difficult for two people to thresh out a difference of opinion than if they were in the same building or group of buildings. This doesn't mean that men have no room for self-expression—they have plenty of it. All that is meant is that when a man is given a certain responsibility and authority be sure that it is clearly stated and that it is generally understood.

When properly set up, the local manager becomes important to himself, to his employees, and to the community. When the newspaper reporter calls, the manager doesn't have to get a release from the central executive office. He is accepted by the Chamber of Commerce and the service clubs as the head of another business. He doesn't have to get permission to engage in Community Chest, Red Cross, or other local drives.

Practically every one of our numerous plant managers is an active member of Rotary, Kiwanis, or the Lions. They are taking leading parts in fraternal orders, community drives, Y.M.C.A., Boy Scouts, and political clubs. Among our plant managers are bank directors, members of borough councils, and members of any number of civic committees and groups.

Such men in a large factory would have charge of but a section and would have but a fraction of the responsibility as well as personal dignity and standing within the community. They would not be the company to anybody. They would merely be supervisory employees.

Decentralization's first contribution to the Age of Man is the building of men at the management level.

WHAT HAS DECENTRALIZATION DONE FOR THE RANK AND FILE?

Concentration, mechanization, and production lines naturally call for less skill on the part of some workers, thereby giving these individuals less and less opportunity to be personalities or to have the incentive to produce more and better. As workers become separated from management, mutual respect and confidence decrease and eventually cease.

When workers feel that they are no longer personalities but, in effect, are mere numbers and that the big boss doesn't know them or what they are doing, how much enthusiasm can they put into their work or how much loyalty can they really have for the company that employs them? Is it not natural for them under such conditions to merge themselves into a mass personality through a labor organization?

Add to this loss of occupational personality the living conditions of a big industrial city where so many of the people live in small and unattractive quarters and we have the makings of a first-class mass feeling of frustration. If people get no enjoyment out of working or out of living, if all is colorless and uninteresting, are they not fertile soil for sowing the seeds of discontent?

In a small plant, the manager has to live with his people. They go to the same church or lodge, their children to the same school. There is no separate social level so that there is a closer personal bond between management and worker. The plant manager must get along with his people, and the more he is liked, the more will the workers try to help him make a success in the operation.

After all, one cannot bowl on the same team with the plant manager, or one's wife be on the same church committee with his wife, or one's son dance with his daughter and feel that there is any great class distinction. There cannot be any such distinction, for workers and managers must live as neighbors. There is no specific area where either group lives. There can be no doubt but that the friendly relationship, as one of our plant managers expressed it, which is nurtured over the garden fence carries over into the job.

Under such circumstances there can be no feeling of frustration, because workers and management belong to the job—

they are a team and how natural it is then for them to take an interest in the work.

As another of our plant managers put it, "Co-operation and friendship from plant manager to the sweeper helps greatly to develop the necessary sound labor relations that every company must have if it is to prosper and grow."

Thus decentralization restores a working personality to labor and a dignity. Work is once more fun and people are happy in their employment.

COMMUNISM CAN NEVER TAKE ROOT WHERE PEOPLE ARE HAPPY

People in small and medium-sized communities lead a much more natural and normal life than those in large cities. For one thing, they can get to work easily and quickly. The average for our small plants is between 10 and 20 minutes.

Instead of paying for their amusement they make most of it themselves and thus are more sociable. They can fish and hunt and work in their gardens. They can play ball or golf or tennis at their own club. There is so much they can do in their leisure time that is clean and wholesome.

In one of the counties near where we have a plant there are said to be more deer than inhabitants. It is not unusual for one of our people to go fishing after work and be back home in time to have the catch for supper.

In the larger industrial centers there is less to do in one's leisure time, especially if one lives in a rented tenement or apartment. Knowing few people in the neighborhood, the desire for company takes fellows to pool parlors and bars. Of course small towns have these too, but they don't get the same patronage. How easy it is to gripe when you have nothing interesting to occupy your time! How easy it is under such conditions to get cockeyed ideas! People are clean-minded if you put them in clean surroundings.

People in smaller places have a greater respect for government and for law and order. It may be because the form of government is simpler, or it may be because everybody knows everybody else, or it may be because they cannot afford a large paid municipal organization—whatever it is, people in smaller places have a greater sense of responsibility for civic affairs.

For one thing, workers can participate in government. We have several such instances in our own operations. One man was mayor; several have been on borough councils and school boards.

People take a greater interest in politics in smaller places and have an opportunity to be on the inside—maybe holding office in a party. Voting is a responsibility in a small place.

People also have a greater opportunity to work for the good of the community. Any number of our people have been on fund-raising committees, or in civic associations where they have been called upon to do something. One of our men headed a drive to buy uniforms and instruments for the high-school band. Many have taken an active part in Boy Scouts and Girl Scouts, Y.M.C.A., and the like. Such activities build citizenship. People do not like to destroy that which they have worked for and are a part of.

In smaller plants, people are thrown closer together and have a better opportunity to understand the relationship of their work to the whole. Instead of their jobs being meaningless dull routine, they can see that what they are doing is important. Their work becomes more interesting.

Some employees who have worked in both large and small plants have told us that they like the smaller operations because people are brought closer together and a more friendly atmosphere is created. With it, they say, they find a spirit of helpfulness, co-operation, and fellowship. People cannot feel loss of occupational personality where friendliness is the rule.

With a close working relationship between employees and between workers and management, such as has been described, there is less room for misunderstanding. It has been our experience that labor relations, as a result, are on a much higher level than those in plants where management is far removed from the working force. The number of grievances is smaller and trouble arises less frequently.

Management having of necessity a greater respect for the workers as human beings cannot help reflecting that point of view. Labor being quick to sense any such attitude reacts accordingly by having a high regard and respect for the company, especially when they hear workers in other plants gripe about the indifference of the treatment they receive. Decentralization provides the mutual confidence that is necessary if we are to avert social disturbances.

OVER-ALL BENEFITS TO COMPANY AND COMMUNITY

While it is true that decentralization offers the manufacturer a fresh labor supply and one that can be checked more readily for references, it also offers people in smaller communities an opportunity to find gainful occupation without breaking up their homes. Thus by moving into smaller places, industry is contributing to a better distribution of employment and to a better balance of market and economy between dense and less heavily populated areas.

However, plant locations should be picked selectively in areas where the supply of labor is not only adequate to the need but where the introduction of a plant will not produce a localized labor shortage of the type of people required.

Aside from the economic benefits to be gained from a well-thought-out program of decentralization, results to date indicate that it offers a practical means of re-establishing the dignity of the worker as an individual. It can develop a mutual respect between workers and management and give a new meaning to the responsibility of employment and the fun of work. It can give more enjoyment to leisure time. It can build citizenship and pride of government. It can be a powerful means for combating the industrial unrest and discontent upon which communism feeds.

Such is the social concept of decentralization—the beginning of the Age of Man.

Labor-Management Conflict

(*Continued from page 531*)

more important, is Dr. Gomberg's dispassionate and scholarly approach to the question of time study. Heretofore, unions have ranted against it instead of studying it with scientific detachment.

Dr. Gomberg's analysis is addressed primarily to the time-study practitioner. It is divided into two parts: (1) Part one examines the theoretical requirements for a science of time study; (2) part two examines how closely existing industrial time-study practice comes to the scientific ideal.

Aside from its technical contribution to the subject of time study, Dr. Gomberg's book is of importance to the broader field of industrial relations. It suggests a method by which labor and management can get together. It provides management with a carefully documented and reasoned statement of a union's attitude toward time study. And by training and experience in setting production standards, Dr. Gomberg is well qualified to make such a study. It is immaterial whether or not management representatives accept all his conclusions. If management experts disagree they can effectively challenge his conclusions only with scientific statements. Whenever management and labor can meet on this objective plane, talking sense rather than sentiment, there is hope for genuine and lasting progress.

BRIEFING THE RECORD

Abstracts and Comments Based on Current Periodicals and Events

COMPILED AND EDITED BY J. J. JAKLITSCH, JR.

MATERIAL for these pages is assembled from numerous sources and aims to cover a broad range of subject matter. While few quotation marks are used, passages that are directly quoted are obvious from the context and credit to original sources is given.

Unified Engineering Society

FOR the past two years the Engineers Joint Council, of which The American Society of Mechanical Engineers is a co-operating member, has been studying the organization of the engineering profession. This study has been focused largely on the needs for a national form of organization that will more properly serve the engineering profession in discharging its professional responsibilities. The hope exists in some quarters that a single over-all national society, or its equivalent, which will concern itself with the common interests of all engineers, may eventually be organized.

An interesting article along these lines by Percy Parr, regarding the situation of civil engineering societies and institutions in Great Britain, appears in *Engineering*, March 5, 1948. In it Mr. Parr has the following to say about British professional engineering societies:

"The current issue of *Whitaker's Almanack* mentions no less than 24 institutions or societies connected with professional civil engineering, and who can say that no more new fields or branches of engineering will be discovered in the future? Dare we hope that the 24 societies will not increase? Is it possible for one institution to be formed to cover all branches of civilian engineering? Let us examine the reasons why new institutions are formed. Is it because some members believe that the parent institution is not in touch with, or cannot adequately cope with the demands of a section of its members; or is it because certain ambitious men wish to take part in the government of an institution and see little hope in the parent institution and assisted by the alphabet chasers, want a new institution? On the other hand, a new institution may be formed as the result of a genuine keenness for the well-being of engineers. Whatever the reason, this policy of splitting into sectional institutions, if it continues in the future at the same rate as it has in the immediate past, will bring such a lowering of status and cheapening of qualifications that, for the majority of engineers, the future will be one of degeneration and uncertainty.

"It is obvious that we cannot continue in this way and that a halt must some time be called; in fact, our steps must be retraced if the future is to be worthy of our profession. But by whom shall the halt be called? There is no other answer to this than that the major institutions should foregather and consider what action should be taken, for, in the interests of the profession of engineering, we must have unity: a unity which will see to it that the engineer of the future is provided with the best of training, literature, experience, and qualifications. This unity can be achieved only if we civilian engineers are prepared to drop our individuality in our institutions and branches and combine in one professional society capable of covering all activities of civilian engineers. I am confident that if we had the courage to dissolve the scores of subsidiary and sectional institutions now vying with one another for recognition and to reconstitute those institutions in one comprehensive and corporate body, future years would fully justify our action and any sacrifice of individual status would be amply rewarded.

"Every effort should be made gradually to eliminate the less important bodies and to merge their activities in a few, and ultimately in one all-embracing institution which would represent every branch of engineering, however novel and however specialized. This single institution, which would be the crowning glory of the profession, would function with the universities and would control the training of students, maintain the standards of efficiency, disseminate the results of the experience and research of engineering in all its branches and, generally, be the authority in all matters concerning the profession of engineer."

Tonnage Oxygen

THE successful development of a new process for the manufacture of tonnage oxygen has been revealed by the Elliott Company, Jeanette, Pa. This development consumed approximately three years and has culminated in the completion of a pilot plant for 95 per cent purity gaseous oxygen. See frontispiece, page 502. The Elliott process is said to be a completely new system and differs in principle from systems developed abroad and now used in this country

According to Elliott, the outstanding features of the process are as follows:

1 The plant is not subjected to the necessity for periodic shutdowns for deriming in order to remove accumulated deposits of water and carbon dioxide. This is important when oxygen is to be used in a process which must be kept on stream continuously.

2 The system is completely immune to possible dangers of acetylene explosions since this system provides a straightforward and simple mechanical means of eliminating dangerous hydrocarbons from the system.

3 The process operates at reduced loads without sacrifice of efficiency.

4 The system is mechanically simplified. Like many other oxygen processes it depends upon reversing heat exchangers to precool the air to liquefaction temperature and at the same time freeze out water vapor and carbon dioxide. These accumulated deposits are periodically removed by reverse flow of effluent nitrogen. In this system these reversals take place every three to four hours instead of every two to three minutes as is common in other known systems. Heat exchangers in this system require only one hot and one cold gas as contrasted to the multifluid exchangers required by existing processes. The switching valves in this system function less frequently than in other systems, and are also designed to operate at only slightly

above atmospheric pressure. This feature reduces maintenance cost and gives added assurance of long life in service without mechanical failure.

5 All controls are automatic. They can be set to maintain constant purity over the entire range of operating conditions, or the purity can be varied at will by a simple adjustment. The automatic controls on the plant can be arranged so that the oxygen plant will automatically follow the process demands for oxygen without requiring manual attention from the operators.

6 The recovery of oxygen from the air is more than 97 per cent, with the result that minimum power is wasted and the nitrogen leaving the process is sufficiently pure for use as a chemical raw material for the manufacture of ammonia, nitric acid, fertilizers, or other processes requiring high-purity nitrogen gas. The system will simultaneously produce high-purity oxygen and high-purity nitrogen.

7 Oxygen as pure as 99.5 per cent can be made by the process. For tonnage production of commercial purity oxygen, analysis shows that it is more economical with the Elliott cycle to make 95 to 97 per cent purity oxygen and to dilute the product as required for the subsequent process. A plant designed for 95 per cent purity can also simultaneously produce 99.5 per cent purity welding-grade oxygen in quantities as required for this purpose.

It is stated that the power requirements and capital cost for the system should compare favorably with other systems.

The Elliott process is a truly low-pressure system in which the air is compressed to about 5 psig, conditioned, and cooled to below 300 F, and charged to a single fractionating column. The complete distillation takes place within this column which operates only a few pounds above atmospheric pressure. The entire plant is controlled by temperature distribution and liquid levels within the fractionating column so that all controls can be related to the desired purity and optimum distillation conditions for minimum power consumption. The gaseous oxygen is boiled off from the reboiler and delivered as the product at approximately atmospheric pressure after having been warmed up to room temperature in a heat exchanger. Effluent nitrogen from the top of the fractionating column which contains not more than $\frac{1}{2}$ of 1 per cent oxygen is used to provide the refrigeration for precooling the air entering the process. A small portion of this nitrogen is used for the removal of the deposited impurities from the heat exchangers while the bulk of it is available at approximately 99.5 per cent purity as a nitrogen product.

Like other oxygen systems refrigeration at extremely low temperature levels must be provided in order to make up for the warm end-temperature losses and the heat leak through the insulation into the system. This is accomplished in the system by an external refrigeration cycle which recirculates pure nitrogen from the top of the column through a heat-exchanger and compressor system, and finally obtaining the required amount of refrigeration by expansion through an Elliott turbo-expander. This same external refrigeration system is also arranged to produce the liquid-nitrogen reflux required as overhead in the column for distillation. The unique arrangement of components provides for control of the refrigeration and reflux independently of the quantity of air being charged to the system for distillation, so that the controls will automatically compensate for changes in demand and weather conditions for uniformity of product and minimum use of power.

The Elliott pilot plant has completed a continuous nine-week run during which time the operation was entirely automatic except during periods of obtaining special test data. The performance confirmed the correctness of design and from the analysis of the data obtained it was demonstrated that the plant could run indefinitely. Regular acetylene analyses were made throughout the process and at no time was any trace of acetylene ever found in the liquid oxygen where the explosion hazard would exist.

The possibilities of these oxygen plants are intriguing and commercial plants are envisioned which will produce more than 25,000,000 cu ft (1000 tons) of oxygen per day. It is expected that with the use of oxygen the output and economy of open-hearth furnaces, blast furnaces, Bessemer converters, and electric furnaces can be greatly increased.

Quantity oxygen is also an essential of the new synthetic-gasoline processes which are being planned. The use of oxygen combined with natural gas opens up a new source of supply of much-needed gasoline, fuel oil, and chemicals. Coal can also be used instead of natural gas, in the production of gasoline and fuel oil, and it is said this development can make the United States entirely independent of the rest of the world for liquid fuels for possibly as long as 1000 years. Even substitute natural gas can be made right at the mines by the gasification of coal through the use of oxygen, and piped to large cities and industries.

Radioactive Tracers

A NEW phase in use of radioactive tracers for industrial research is indicated by the recent completion of what is said to be the largest tracer experiment ever conducted, and probably the first using full-scale industrial equipment. Sponsored by the Republic Steel Corporation, the experiment was conducted in their Cleveland, Ohio, plant by Arthur D. Little, Inc., Cambridge, Mass. The use of tracers in industry is reported to have increased greatly in the year and a half since the Atomic Energy Commission has made many new kinds available at lower prices.

The recent study was one step in a program for keeping undesirable sulphur out of steel, and is typical of the instances where tracers are especially useful. Sulphur enters steel in many ways—with the coke derived from coal, or with ore, limestone, scrap, or fuel oil. Some of it leaves the system in slag or flue gases, but some reaches the finished steel. In the finished steel, one cannot tell which raw material supplied the sulphur, except by tedious and inconclusive statistical correlation of sulphur content of the raw materials with that of the steel. This method showed coal to be the chief cause, but steelmakers still were not certain which of the chemical forms of sulphur in the coal got through to the coke and then entered the blast furnace.

There are two important forms of sulphur in coal, pyritic and organic. Since the forms change in the coke oven, there is no chemical method for learning whether the surviving sulphur in the coke came from the original pyritic or organic sulphur, or whether low-pyritic coal or low-organic coal is the better raw material. If one of the forms is tagged with radioactive atoms, however, its travels can be followed very precisely with radioactivity counters. In the present work, a small amount of artificial pyrites was made from radioactive sulphur and thoroughly mixed with 12 tons of coal, the normal charge to a coke oven. The proportion of the coke's sulphur which had come from the pyrites was then found by measuring the radioactivity of the sulphur. This proportion was about the same as in the original coal, indicating that both forms are carried over to the coke equally, and that there is no advantage in buying coal with a low pyritic-sulphur content. More tests are planned to trace sulphur in other materials and chemical combinations through the steelmaking process.

Radioactive tracers have also been used in determining the concentration of toxic fumes in industrial plants, measuring the

lubricant applied to textile fibers in amounts so small that ordinary measurements fail, determining the minute amount of metal transferred when a shaft rotates in a bearing, and studying the mechanism by which plants produce food from carbon dioxide, water, and other nutrients by photosynthesis.

Use of tracers to control industrial processes is being considered. As an example, radioactive phosphorus added to a Bessemer steel furnace would show when the last impurity, usually phosphorus, had been removed from the steel. Automatic controls could also be connected electrically to radioactivity-measuring instruments to turn down and shut off the Bessemer at the right time.

Research with tracers is characterized by directness and simplicity. Often, as in the coke-oven work, the experiment can be run in full-scale equipment. This is important, for there is sometimes serious doubt whether a conclusion reached in the laboratory will hold in the plant itself. Radioactive materials from the atomic pile are not expensive. The sulphur for this study cost about $50, compared with thousands of dollars prewar, when radioactive materials were made in the cyclotron. Better measuring instruments are available now, and more technologists are familiar with radioactivity.

On the other hand, not all elements have radioactive forms suitable for tracer uses. For example, radioactive oxygen loses about half its radioactivity every two minutes. Many important radioactive elements are not available from the atomic pile, and must still be synthesized in a cyclotron at much greater cost. The AEC restricts purchase and use of radioactive elements to protect the experimenter and the general public against misuse. The Commission considers the applicant's professional qualifications, the instruments available for safeguarding health, and the intended use. The requirements of the AEC reflect the danger possible with radioactive materials. A properly planned experiment should involve precautions such as the use of a minimum amount of active material, appropriate shielding, avoidance of inhalation and ingestion of the material, and safe disposal of all waste containing active materials.

Mildew Prevention

A FUNGICIDAL dressing for the treatment of leather goods, developed by the National Bureau of Standards, is said to provide complete protection of such goods from mildew. The growth of mildew on finished leather has previously been regarded as only a slight annoyance since, generally noticeable only during the summer months, it was believed that it caused no deterioration. Conditions in the South Pacific were, however, so favorable for its growth that it was necessary to develop preventive treatments for the use of the Armed Services personnel stationed in those areas. The Bureau's leather-dressing compound has proved so effective that it is finding widespread application and has been incorporated into various government specifications.

The important ingredients of the new dressing are 20 per cent of a mixture of equal parts of neatsfoot oil and mineral oil, for amplifying and preserving the flexible characteristics of the leather, and 2 per cent of paranitrophenol, a fungicidal material for preventing the growth of mildew. The other components are 10 per cent cyclohexanone, used because of its solvent power, and 68 per cent of either perchloroethylene or Stoddard's solvent. Perchloroethylene is preferred because it is noninflammable. The compound should be applied so that the amount of the active ingredient (paranitrophenol) is not greater than 0.35 per cent of the weight of the leather and should not be used for articles which make intimate contact with the skin such as hatbands and gloves.

It was not uncommon for troops in the South Pacific areas to find heavy growths of mildew appearing on their shoes overnight. Not only is it a nuisance to remove the mildew before wearing the shoes, but it has been demonstrated that the mildew weakens the leather by destroying the oils which maintain flexibility and softness.

The fact that mildew was a particularly difficult problem in the South Pacific areas is evidence that mold growth is a function of atmospheric conditions. Accordingly, practical experiments were conducted which demonstrated that mildew would not grow on leather in an atmosphere having a relative humidity less than 85 per cent, at a temperature suitable for mold growth. Packaging tests followed, and it was found that if leather was properly sealed to prevent absorption of moisture from the air the growth of mildew would be prevented.

Marine Gas Turbines

A GENERAL review of the present position of steam and gas turbines for marine propulsion is given in The Institution of Mechanical Engineers Proceedings, 1947, vol. 157 (War Emergency Issue No. 29), by T. W. F. Brown, Stanley S. Cook, and F. W. Gardner. The paper entitled "Steam and Gas Turbines for Marine Propulsion" was one of the centenary lectures on marine power plant given at the one-hundredth anniversary celebration of The Institution of Mechanical Engineers last year.

The section on the marine steam turbine examines steam conditions and present-day conformations of propulsion units. The gas-turbine section considers possible advantages and discusses the lines of development which are being pursued with particular reference to the open-cycle gas turbine utilizing all rotary turbines and compressors.

It is indicated that the gas turbine is attractive because it offers potentially better fuel consumption than the steam turbine, lower specific weight, fewer auxiliaries, and reduced stand-by losses. Using heavy oil as fuel, it should compete with the Diesel engine which, although at present thermally more efficient, requires the use of higher-grade oil.

The following two lines of development have been pursued:

1 With combustion at constant volume, the gas is provided by a piston engine, working with high supercharge, and exhausting to a turbine which produces the net output of the set. The combustion in the piston-engine portion requires refined fuel oil to be used. In the free-piston type of engine it is difficult to "phase" the separate sets of units, with the result that surging occurs in the gas supply to the turbine. Maneuvering control is also a difficult problem. This type can be regarded only as a stage in the development of the all-rotary gas turbine.

2 With combustion at constant pressure—in which field the most active developments are now taking place—all the working components are of the rotary type. Constant-pressure gas turbines can be subdivided into two classes, according to whether the cycle is "open" or "closed." In the open cycle, atmospheric air is drawn in, compressed, heated at constant pressure in a combustion chamber, expanded as a mixture of air and combustion gas in the turbine, and finally exhausted to the funnel. A heat exchanger is usually interposed to transfer heat from the exhaust gases to the air leaving the compressor. In the closed cycle there is a similar sequence of compression, heating, and expansion, but the working air is continuously circulated, and the exhaust is cooled before passing to the compressor. All heat additions and abstractions are through surface heaters and surface coolers. Although work-

ing with similar pressure ratios to those employed with the open-cycle gas turbine, the actual pressure may be high, with a consequent increase in density that reduces the sizes of the heat exchangers and all rotary components. Large air heaters, however, are required in place of the small combustion chambers of an open-cycle plant.

In England and in the United States the open cycle is generally adopted. In Switzerland there are three firms carrying out research and development for marine propulsion employing the open, closed, and semiclosed cycles.

Generally, axial-flow compressors are used. The only known variants at the present time are compressors of the centrifugal type and of the displacement type, both of which are of lower efficiency than the axial-flow pattern. The axial-flow compressor is more sensitive to speed variation than the other types, but as, in general, the compressor would not be on the same shaft as the output turbine—and therefore not obliged to rotate at the same speed—this is not necessarily a serious limitation.

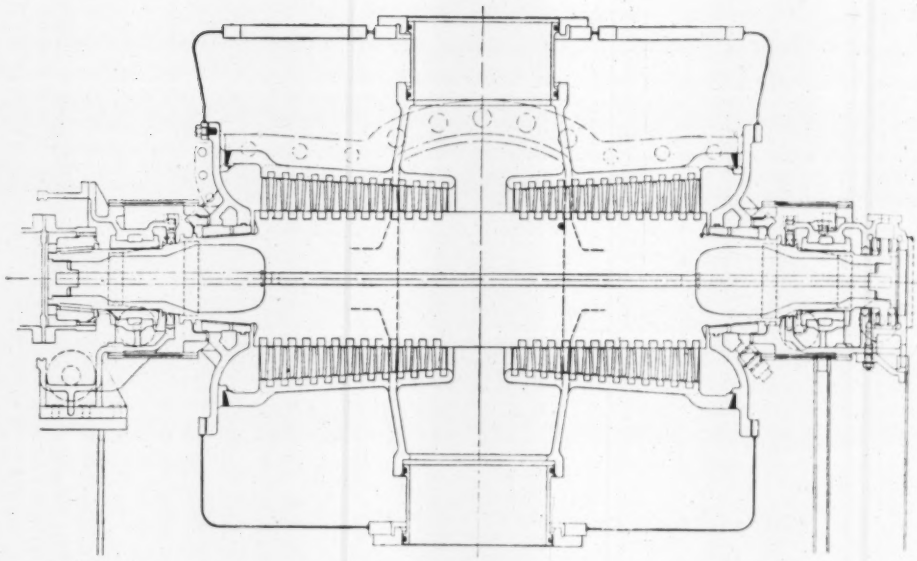

FIG. 1 DOUBLE-FLOW REACTION-TYPE GAS TURBINE

In turbine construction both impulse and reaction types of blading are used, although where long life is a consideration the majority of turbines under construction utilize reaction blading. The distinction between the two, however, is becoming difficult to define, particularly when the vortex design of blading is used. Careful design of the blades is of paramount importance, because the effect on net output of a change in blade efficiency is much greater than in the case of a steam turbine. For example, an improvement of one per cent in the efficiency of both compressor and turbine blading results in a gain of about five per cent in the net output.

The need to keep the stress in the blades to a low figure, to insure a life of 100,000 hr without creep failure, limits the energy that can be liberated per stage. This necessitates a turbine of the multistage type. A double-flow "Pametrada" reaction gas turbine which fulfills these conditions is shown in Fig. 1.

In view of the high temperature of the working fluid, the highest degree of symmetry of the casing is desirable in order to obviate distortion. Special provision is necessary to prevent heat conduction from the body of the turbine to the pedestals carrying the shaft bearings. The large coefficient of thermal expansion of the austenitic materials employed for the high-temperature parts increases the difficulty of maintaining clearances, and the design must be such that heating rates of rotor and casing are comparable.

Combustion chambers are usually arranged to have the flame confined within a central sleeve or flame tube and maintained with about 30 per cent excess air. The additional air, required to reduce the temperature to the final value for admission to the turbine, passes through an annulus outside this sleeve, and mixes with the hotter gases at the downstream end of the combustion chamber.

For marine work over-all efficiencies of at least 25 per cent are required at the shaft, as well as good efficiencies at part load. To obtain such efficiencies with an upper temperature limit of 1200 F, it is necessary to employ heat exchangers. It is difficult to obtain the maximum transfer of heat with the minimum of pressure drop in a reasonable size of heat exchanger. High thermal ratios in a heat exchanger of the surface type can be obtained only at the expense of volume. A thermal ratio of 80 per cent would require a surface about six times that required for a thermal ratio of 50 per cent for the same pressure drop. As, however, a thermal ratio of 80 per cent (as against 50 per cent) would mean a marked reduction in the fuel consumption—probably about 18 per cent—heat exchangers of large volume may be justified.

Such considerations will encourage the development of rotary-type heat exchangers, which, it is thought, can be developed to give thermal ratios as high as 95 per cent with a volume comparable to that of the tubular heat exchanger of 60 per cent thermal ratio.

The rotary type of heat exchanger inevitably involves some loss of working fluid by leakage, and though this may be more than offset by fuel saving obtained with the larger heat recovery, the success of the type depends on a design in which the leakage can be controlled at a small amount, for even a leakage of only 3 per cent reduces output by 10 per cent.

Rocket Exhibit

THE first public exhibition of the Robert Hutchings Goddard rocket and jet-propulsion inventions and research materials, developed during his 30 years of work before World War II, was opened at The American Museum of Natural History, New York, N. Y., April 21, 1948, for a showing of several months. Dr. Goddard died on August 10, 1945, while engaged in rocket research for the United States Navy.

The Goddard Rocket Exhibit makes available to the general public and to engineers and scientists, for the first time, the original rockets and apparatus developed by Dr. Goddard. Today his accomplishments are said to constitute the foundation of the science and fast-growing industry devoted to rockets and jet propulsion.

The exhibit was built under the auspices of The Daniel and Florence Guggenheim Foundation, which supported his work

from 1930 until Dr. Goddard accepted a wartime research assignment for the United States Navy.

The Foundation and Mrs. Esther Kisk Goddard, Dr. Goddard's wife, and for many years his secretary and photographic assistant, are carrying forward activities that will help the United States to realize the benefits of his work.

The exhibit includes the 22-ft Goddard rocket, developed in the 1930's, that incorporates features later found in the German V-2 rocket missiles. It is cut away so that the intricate interior arrangements of fuel lines, pumps, nozzles, injection systems, control devices, and combustion chamber are plainly visible and labeled.

Another large Goddard liquid-fuel pressure rocket, also cut away, is shown. Various showcases display the world's first successful liquid-fuel rocket, fired on March 16, 1926, at Auburn, Mass., and other actual rockets and rocket parts marking other of Goddard's "firsts" in the field.

Dr. Goddard, called the father of the modern rocket, first became interested in scientific exploration of the upper atmosphere while a student at the Worcester Polytechnic Institute, and about 1909 began experiments with rockets as a means of sending instruments to high altitudes to explore the upper atmosphere.

As professor of physics at Clark University, Dr. Goddard continued his experiments, and in World War I he developed an early form of the bazooka rocket and several other military rockets.

Under grants from The Smithsonian Institution and The Daniel and Florence Guggenheim Foundation, Dr. Goddard developed the mathematical principles of rocket motors and rocket flight, and built and shot the first gyro-controlled rockets. The grant from The Smithsonian Institution made possible the publication of his initial computations and research reports in the famous Goddard report published by the Smithsonian in 1919. He patented nearly 150 rocket inventions.

All rockets before 1926 were propelled by solid fuels, such as gunpowder. During World War I, Dr. Goddard became aware of the limitations of solid-fuel rockets, particularly their short range, and turned his attention to the development of liquid-fuel rockets. He was the first man to construct and shoot a liquid-fuel rocket successfully.

This historic liquid-fuel-rocket flight occurred on March 16, 1926, and this rocket is the direct ancestor of the German V-2 and of all other large long-distance rockets. The fuels were liquid oxygen and gasoline, and the rocket was ignited with a blowtorch. It flew for $2\frac{1}{2}$ sec and traveled a distance of 184 ft. Its average speed was 60 mph.

At a time when his rocket experiments aroused the ire of householders near Worcester, Mass., the work of Dr. Goddard came to the attention of Mr. Daniel Guggenheim in 1929. Mr. Guggenheim in 1930 provided funds for the establishment of a laboratory and proving grounds at Roswell, N. M., where much of Dr. Goddard's most striking inventions and rocket flights took place.

The experiments in New Mexico from 1930 to 1940 are said to have laid the foundation for all modern rockets. It was during this period that two large rockets, shown as part of the exhibit, were developed.

In the smaller rocket the fuel was forced into the motor by a pressure storage tank; in the larger one by pumps driven by a gas generator.

A number of other rockets like the smaller one were tested from 1935 to 1938. The maximum altitude reached was about 7500 ft, and the maximum speed was about 750 mph.

Larger pump rockets were first fired by Dr. Goddard in 1939. Both of the rockets shown were shot several times and descended safely by means of parachutes, although they were damaged slightly by fire or by striking the ground after the flight.

In the face of apathy, ridicule, and opposition, Dr. Goddard by his pioneering research, almost single-handed, launched the modern era of jet propulsion. Before his death in 1945, he saw the work he courageously started become world-wide in importance. Virtually every major nation is now engaged in rocket research, particularly the United States, Great Britain, and Russia.

In the United States, rocket research is being carried on by the Army, Navy, and Air Forces with the co-operation of industrial companies, research laboratories, and universities.

Speakers at the exhibit ceremonies were Harry F. Guggenheim, president of The Daniel and Florence Guggenheim Foundation, and J. H. Doolittle, formerly Lieutenant General of the United States Air Forces, and now vice-president and director of the Shell Union Oil Corporation.

Both Mr. Guggenheim and Mr. Doolittle emphasized the vital role of rocket power for peaceful benefits and national security.

Mrs. Goddard of Worcester, Mass., wife of the inventor, unveiled the exhibit.

According to Mr. Guggenheim, The Guggenheim Foundation will pursue its objective of encouraging peacetime uses and a peacetime industry in rockets and jet propulsion through the following program:

1 Making available to those who need it the technical and general information which Dr. Goddard accumulated in his lifelong research in this field. This includes publication of some of the voluminous technical data from his notebooks, the administration of his more than 150 patents and patent

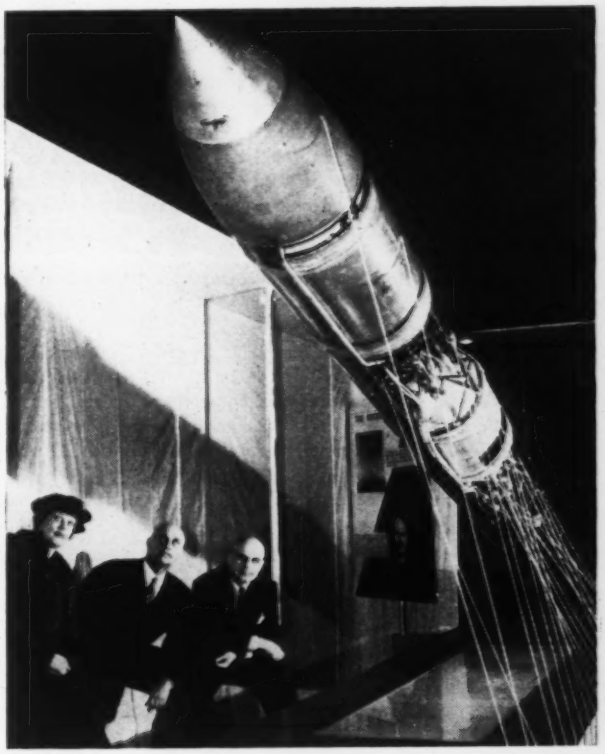

FIG. 2 THE 22-FT LIQUID-FUEL ROCKET, CENTERPIECE OF THE ROBERT H. GODDARD ROCKET EXHIBIT, IS VIEWED BY (*left to right*) MRS. ESTHER KISK GODDARD, HARRY F. GUGGENHEIM, AND J. H. DOOLITTLE

applications in such a manner as to reflect the most benefit upon the rocket and jet-propulsion industry, and the presentation of some of Dr. Goddard's actual rocket material for study, as in the present exhibit.

2 The development of ways to aid in the education and training of new leaders and specialists capable of grappling with the difficult problems of the future in the field of rockets and jet propulsion.

3 Study of possible peacetime uses for rockets and jet propulsion, and stimulation of research and development along these lines.

The Robert H. Goddard Rocket Exhibit will be shown in other centers in the United States following the New York showing, according to plans disclosed by The Guggenheim Foundation.

Magnetic Belt Recorder

RECENTLY a magnetic recorder operating with a new form of record medium was announced by Armour Research Foundation, according to *The Frontier*, March, 1948. The record in this machine is a wide endless belt made of paper and coated with a thin layer of magnetizable material. An invisible magnetic track follows a helical path around the belt as shown (exaggerated) in Fig. 3.

These lines are spaced about $^1/_{30}$ to $^1/_{50}$ in. apart. To produce such a track, the belt is run past a magnetic head, Fig. 4. An erase coil energizes the erase gap with a high-frequency field and cleans off any previous recordings from the belt. The record coil is energized by voice currents picked up with a microphone. These currents produce an alternating field in the record gap which magnetizes the surface of the belt that is in contact with the head.

The area of the belt exposed to the magnetic field is only about $^1/_{60}$ in. wide and $^1/_{1500}$ in. long in the direction of movement. It is thus possible to record a great deal of information in a small area. For instance, a belt which will fold to a standard $8^1/_2 \times 11$-in. size will take approximately 45 minutes of dictation. Business-envelope-size belts have a capacity of about 15 minutes, and correspondence-envelope-size belts record up to 10 minutes.

The erase feature makes it unnecessary to keep a written record of errors made since errors can be wiped out at any time and the corrections recorded in their stead.

Folding does not harm the magnetic record. The belt may be filed as easily as a letter or it can be mailed in an ordinary envelope. Pencil or ink notes can be written on the record, either on the magnetic side or on the paper back. For routine dictation the magnetic surface is good for thousands of playbacks and can be erased and re-used at any time.

Experiments are now being carried out to adapt the belt principle to high-quality music recording suitable for home entertainment use. Higher speed and wider spacing between lines are necessary for this application and a recording of 12 to 15 minutes is obtained on the $8^1/_2 \times 11$-in. belt.

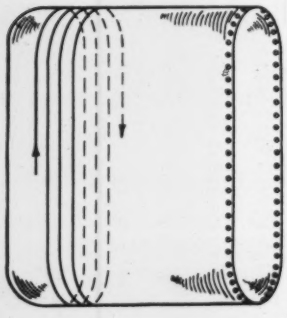

FIG. 3 MAGNETIC HEAD

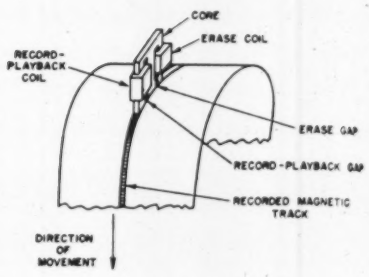

FIG. 4 PAPER BELT FOR MAGNETIC RECORDER

The endless-belt-type dictating machine is past the experimental stage. It has been tested over a period of time in the magnetic recording laboratories of Armour Research Foundation and proved to be sound in principle and operation. Commerical models of the machine are expected to be in production and on the market in the near future.

Materials Handling

ECONOMICS in the handling of materials in industry were discussed by Harry E. Stocker, president, Harry E. Stocker Associates, New York, N. Y., at a Materials Handling Division technical session held during the 1947 ASME Annual Meeting.

Mr. Stocker pointed out that experience with a variety of manufacturing organizations has disclosed many mistakes which have been made because of lack of adequate attention to the economic aspects of the particular handling problem, and the failure to determine the most economical method in each case.

Examples of economies that have been effected show that one American company is saving more than $1,000,000 as a result of thorough planning of materials-handling operations. It was found by careful study of their whole problem of storage and handling that it was possible for them to build a smaller-capacity warehouse and factory than was originally planned.

Another company is saving more than $75,000 yearly by the application of the fork-truck and pallet method of handling in only a small part of its total operations.

Actually, many men can be saved and worth-while economies effected by using modern materials-handling equipment. Usually the slowness with which the possibilities of making savings in materials-handling operations are realized is caused by lack of understanding of its importance and of its fundamental principles.

General studies indicate that on an average, 59 tons of material are handled for every one ton produced—the high ratio due largely of course to repetitious handling.

Mr. Stocker said that an important factor in making improvements in materials-handling operations is the approach to the problem. For example, a company can decide it needs fork-truck pallets, call in a salesman, pick out one model, and buy it. In almost every case the company will save money, but the important thing is to save the maximum amount of money with the least investment.

Good materials-handling engineering takes into consideration the basic principles associated with the materials handled, and acts on these principles in analyzing an operation, whether only a small amount of material is being handled or huge quantities are to be moved.

In surveying materials-handling operations, it is helpful to have all the principles in mind if maximum economies are to be obtained. As a plant, warehouse, mill, or railroad terminal are surveyed with these principles in mind, the minimum possibilities can be determined quickly.

In one plant, a preliminary survey indicated that the company should be able to save more than $100,000 a year by improved materials-handling operations. The management was informed that a minimum of $50,000 could be saved. After such an initial survey, a detailed analysis was made and a complete detailed report with recommendations submitted. The resultant saving was nearly $200,000 a year.

He also stated that it is important to study alternative ways of attaining economies in order to save a maximum amount of money. Reduced operating costs, increased production, reduced damage to materials, or a combination of these are such factors. In one case, a plant manager wanted to install a conveyer underneath the street to carry materials from one building to another. He did not insist on such an installation, however, but wanted to obtain the most economical solution.

A fork truck of special design was recommended that would do everything necessary, save $15,000 in the cost of the equipment as compared with the conveyer, and save the cost of constructing a tunnel.

By use of the fork truck it was possible to move the material in one operation from warehouse to factory and from the warehouse to other parts of the plant. Moreover, if at any time in the future it was decided to abandon the original operation, the truck could be used elsewhere in the plant or could be easily resold.

Mr. Stocker pointed out that the matter of space economies is one which needs emphasizing. Companies often build excessive plant facilities because materials-handling methods are not properly understood. The proper approach is to make a thorough study of the materials-handling operations before building the plant or warehouse. On the basis of such a study, economies can be effected.

Use of all sources of information about equipment and methods is important to gain maximum economies. First in importance is a man's own experience in his own plant. Second, find out what other people are doing by spending some time visiting their plants, not only in the same industry but in other industries. Third, follow up the activities of technical societies such as the ASME. Trade papers, on the whole, also do an effective job of presenting good practical information through articles on materials handling.

Other effective sources of information are as follows: corresponding with others working on materials-handling problems, the available motion-picture films, equipment salesmen, government agencies, materials-handling shows, and the consultant.

A consultant is valuable because he has diversified experience. The properly qualified consultant has worked in many industries in different parts of the world and can give information on designing, on new equipment, and new methods of meeting problems. The consultant is, in a way, a clearing house for information.

One of the biggest problems is getting exact facts with a minimum of effort and time. The first approach to a problem is to make a detailed study of the operation, get the facts, and save the company some money. Next, make a flow chart and develop particulars for saving more money.

The determination of economies effected cannot be determined accurately where the return is indirect. A reduction of accidents is worth while but difficult to measure in amount of savings. Reduction of damage to materials is often difficult to measure accurately, bur it is worth while. Many plants increase production by reducing damage of products after production.

In closing, Mr. Stocker stated that we must have a more rapid and more complete interchange of information on materials handling and a more thorough understanding of fundamental principles to achieve the maximum savings for industry.

Heat-Flow Analyzer

AN improved analyzer which will take the guesswork out of many industrial and scientific problems was revealed recently at Columbia University, New York, N. Y.

The question of when to extract a bad tooth may be determined in the engineering laboratory long before the dentist peers into a patient's mouth, and geologists in the near future may be able to compute the geological age of the earth by exact methods also determined by engineering techniques.

These and countless other unrelated problems, it is said, can conceivably be solved by the device which has already helped industry remove the element of guesswork from problems relating to heat flow. It is a specialized type of calculating machine developed at Columbia's School of Engineering and is known as a "Heat and Mass Flow Analyzer Laboratory." Equipment in the laboratory, which was originally established in 1940–1941, has just been rebuilt and its facilities greatly increased. The original Columbia analyzer was described and the theory explained in ASME Transactions, vol. 64, 1942, page 105.

As a result of these improvements the calculating machine is now prepared to undertake many unusual projects, according to Dr. Victor Paschkis, Mem. ASME, technical director, and Associate Professor Carl F. Kayan, Mem. ASME, administrative director of the laboratory.

Conversations with dental scientists resulted in tentative plans for joint research, with the hope of correlating the time for a patient to sense a specified change of temperature with the thickness of the still healthy part of the tooth.

Conversations with various geologists resulted in the opinion that the technique of the laboratory could be successfully used to determine the geological age of various parts of the earth. Applying the time-scale technique, it would be possible to "condense" the probable millions of years which were required for the earth's crust to solidify into a few hours in the laboratory.

This almost magic ability of the calculating machine to circumvent the barriers of time, space, and material substance is one of the analyzer's most important characteristics. Its principle is based on the "electric analogy" method, which means that flow of heat is measured in the same way as electric current. This makes it possible to use what is termed the "lumping procedure" of electrical measurements—a technique that permits measurements to be made by concentrating the properties of materials in individual circuit elements such as resistors and condensers.

It is said that samples of material to be tested do not have to be used directly. All that is required are the "thermal" properties of the material involved and their size and shape.

During the last six years the laboratory has undertaken many problems submitted by industry. Among them have been the following: Heat flow of regenerators, such as are used in the steel and glass industries; heat-transfer problems involved in the solidification of metals, such as castings and ingots; analysis of heat losses in furnaces; the problem of de-icing of airplane windows at high altitudes; heat generation of brakes on trains and airplanes; and specific heat-flow problems of industry, which have been solved by use of the analyzer as a calculating machine.

The general program of fundamental research is carried on under the following five categories: (1) Setting up of charts and graphs on heat-conduction problems; (2) solution of problems involving complicated shapes with heat flow moving in two and three directions, whether temperatures change or do not change with time; (3) analysis of heat-transfer coefficients in finned heat exchangers; (4) development of a method to study quenching of steel and other metallic and nonmetallic materials; and (5) solidification of ingots.

The laboratory is said to be the first of its kind in the world. Several smaller versions have been modeled after it, both in this country and abroad.

Locomotive Developments

A REVOLUTIONARY "free-piston" gas-turbine engine for a railroad locomotive and a new steam-turbine electric locomotive that it is hoped will reduce coal consumption by one half are among four new railroad engines under development by Westinghouse Electric Corporation.

The third, reported Gwilym A. Price, president of the Westinghouse Electric Corporation, in an address before the New York Railroad Club, is a new and larger electric locomotive. The fourth, previously announced, is a gas-turbine electric locomotive designed to burn liquid fuel and operate in mainline service.

In addition to these four projects, Mr. Price revealed that Westinghouse is "aggressively" pressing research to determine if coal-burning gas turbines for locomotives are feasible.

Most novel departure in railroad propulsion is the free-piston gas-turbine engine, but most significant to the nation's coal-burning railroads is said to be the steam-turbine electric drive.

This project is being undertaken jointly with the Babcock & Wilcox Company to develop an improved type of steam-turbine electric locomotive utilizing an efficient, compact, high-pressure, high-temperature boiler.

The free-piston experimental development is being undertaken in collaboration with the Lima-Hamilton Corporation, Hamilton, Ohio. Lima-Hamilton has been experimenting for some time with a new form of gas generator of the free-piston type designed to provide extremely high efficiency.

Their experience has been sufficiently encouraging for them to ask Westinghouse co-operation in the construction of a free-piston gas-turbine locomotive for trial service. For this, they will provide the gas generator that takes the place of the compressor and combustor, and Westinghouse will provide a 3000-hp gas turbine, the electric generators, motors, and control.

In this type of power plant, it was explained, opposed pistons travel back and forth in a cylinder. Unlike the pistons in an automobile engine, these are not connected to a drive shaft and their function is to supply hot gases for the turbine. A firing chamber in the center keeps the pistons flying back and forth, compressing air, burning fuel in this compressed air, and releasing hot gases at each stroke.

It was revealed that Westinghouse engineers have developed the essential outlines of a new and larger electric locomotive at the direction of the Pennsylvania Railroad.

It is said to be about one half more powerful than the present largest electric locomotive and is ideal for the movement of heavy freight traffic. Because all weight is evenly distributed on 16 axles, each powered by a separate motor, this locomotive is reported to be capable of pulling heavy loads without wheel slippage and, it is said, it will enable the railroad to haul its heaviest trains with a single unit and maintain, or better, present running time.

For this locomotive, new motors, smaller, better-insulated and more efficient, were developed. New transformers have high capacity for a given weight because they employ the new war-developed silicone insulation that withstands high temperature. Superior transformer steel is used. Electric braking will hold back trains on descending grades. The new locomotive would be built in standardized units, similar to Diesels.

Discussing the gas-turbine locomotive, Mr. Price asserted that Westinghouse "believes very firmly" in its future and expects to have one running some time in 1949.

He said that while our first gas-turbine locomotive will burn liquid fuel, "we are not overlooking the possibility of making a coal-burning gas-turbine locomotive. For two years we have been conducting experiments with pulverized-coal combustors and are continuing the research aggressively this year in a new direction. While we cannot say we are yet ready to throw our hats in the air over what we have found, we are going to prove to our satisfaction that a gas turbine either can, or cannot, burn coal."

Mr. Price listed the following advantages for a gas-turbine electric locomotive power plant:

Larger horsepower can be concentrated in small space. The amount of lubricating oil is materially reduced, and other problems encountered with reciprocating engines are eliminated.

The gas turbine can burn any kind of liquid fuel. The unit requires no water and has no ash problem. The gas turbine is the essence of simplicity and compactness and offers unequaled accessibility for servicing.

While the fuel economy of the present type is not as good as for Diesel engines, the difference in fuel consumption is offset by simplicity, lack of reciprocating parts, ability to use cheaper fuels, and virtual elimination of lubrication problems. It will make possible the construction of locomotives with two thirds the weight and one half the length of Diesel electrics.

Full-Scale Fatigue Testing

THE design of machine components by full-scale fatigue testing was described by C. B. Griffin, assistant head, and A. F. Underwood, Mem. ASME, head, mechanical engineering department 5, research laboratories division, General Motors Corporation, Detroit, Mich., at a Metals Engineering Division technical session during the 1947 ASME Annual Meeting.

The authors pointed out that in recent years, engineers have found many advantages by designing machine components on the basis of fatigue tests conducted on production parts. The resultant effects of numerous factors, such as, fillets, heat-treatment, trapped stresses, and dimensional tolerances, are evaluated in terms of useful life or maximum load. In addition, although such factors are frequently specified on the blueprint, actual production may result in serious deviations which cannot be properly assessed except by full-scale testing.

In the General Motors Research Laboratories, a machine has been developed which applies an alternating load to the component under test. (A description of the machine appears in an article, "A Machine for Fatigue-Testing Full-Size Parts," by C. B. Griffin and A. F. Underwood in the Proceedings of the Society for Experimental Stress Analysis, vol. 4, no. 2, p. 32.)

Briefly, hydraulic forces are used to develop any combination of tension, compression, and torsion loads. Tension and compression loads up to 200,000 lb and 20,000 in-lb torque can be attained. These types of loading can be applied separately if desired. After the machine has been adjusted and the operating temperatures are stabilized, it can usually be left unattended for 12 to 20 hr at a time.

When the service loading is known, it is relatively simple to make the proper fixtures to hold the piece to be tested so as to reproduce the loading in the machine. By applying an overload, the failure point is reached in a shorter time and a typical S-N curve can be determined; these possibilities aid greatly in rapidly developing a good design.

When a part has been failing in service at a particular section with a known locus of failure, it may be necessary to use strain gages and lacquer coatings to investigate how the forces are applied. Through the use of such devices, the proper combination and point of application of the forces or torque can be made. To show how these methods have been used and how improved machine components have been developed, several design problems are considered by Mr. Griffin and Mr. Underwood.

COMPONENT UNDER TENSION AND COMPRESSION

Before the start of World War II, the Allison engine was being increased in rated horsepower output and one important part which had to be investigated was the connecting rod. The fixture shown in Fig. 5 was made to hold the part in the machine so the tension-compression loads could be applied. The first "forked" rod was tested under 25,000 lb compression and 12,500 lb tension, equivalent to 150 per cent of engine load at 1000 hp. It was immediately apparent that the crotch design would be unsuitable for increased engine output because failure developed after only 750,000 cycles. As the rod was visible at all times, the origin of the fatigue crack could be seen and its progress could be followed across the section. The short life was caused by the sharp radii at the inside of the fork, which were connected by straight lines. By changing the contour of the crotch to a uniform radius, the life was extended to no failure as shown in Fig. 6.

At first the crotch was produced with a very uneven radius whereas a smooth radius had been specified. Under a load of 25,000 lb compression and 12,500 lb tension, this rod failed in 1,743,460 cycles compared to a full 10,000,000 cycles with no failure for all other rods of this type but having the proper radius. The life was increased further by shot-peening the surface. See Fig. 6.

By this time the load had to be raised to set a new base line. With the shot-peened connecting rod, the 1710 Allison engine was raised from the original 1000 hp to more than 2000 hp. However, it was found that by nitriding the surface, the connecting rod was capable of sustaining still heavier loads. This is also indicated in Fig. 6.

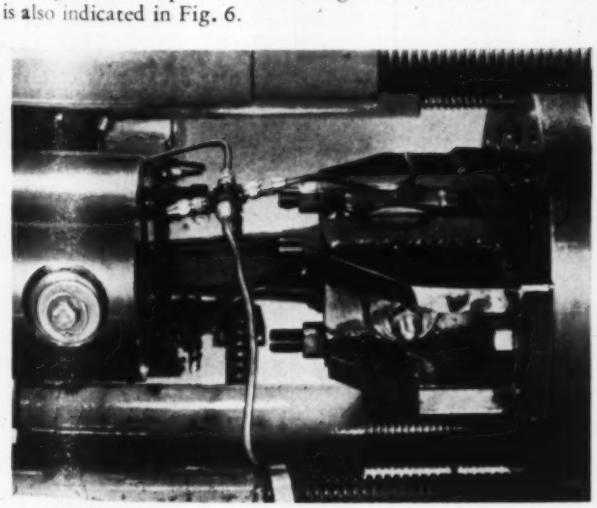

FIG. 5 CONNECTING-ROD SETUP IN FATIGUE-TESTING MACHINE

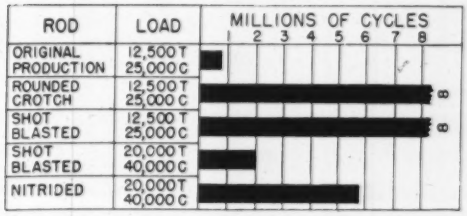

FIG. 6 EFFECT OF TREATMENT AND DESIGN CHANGE ON FATIGUE LIFE OF FORK ROD

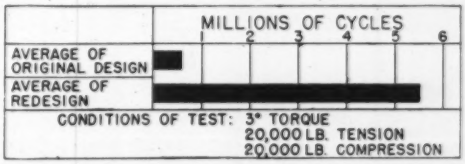

FIG. 7 EFFECT OF INCREASED FILLETS ON LIFE OF BLADE ROD

TORSION ADDED

Next it was learned that several failures in test engines had shown a unique location of the crack nucleus in the rod column near the wrist-pin end. Through the use of a surface strain-measuring gage, the rod was found to require a torsional couple on the column to reproduce the stress location. When the test machine was equipped with a special "torsion attachment," the failures were exact duplicates of those on the test stand. This portion of the investigation was made on blade rods but it should be pointed out that the upper-end design is the same for both fork and blade rods. When torsion was applied in conjunction with tension and compression, the rods failed in a few cycles.

Knowing the source of the difficulty, a new design with a fuller blend from the column flange to the piston-pin boss was made. Fig. 7 shows that an effective improvement resulted. No further failures in high-output test engines occurred. In general, the changes in rod design were minor at first glance in that the first and last rods weighed practically the same amount. But through the use of full-scale testing, the least metal could be added to secure the greatest gain.

STRESS UNDER OPERATING TEMPERATURE CONDITIONS

Another interesting war project was the testing of a threaded joint used to hold the head to the cylinder barrel of an air-cooled Ranger aircraft engine. The problem was to determine which one of several designs would give the longest and most uniform life. Each cylinder assembly, with valves in place, had the combustion space filled with a special lead-tin alloy. A piston and connecting rod were placed in the normal location and in contact with the lead-tin alloy. The cylinder assembly was bolted to the stationary plate of the fatigue-testing machine and the connecting rod was attached to the actuating member of the machine. An alternating force of zero to 20,000 lb compression was applied. The cylinder head was heated by thermocouple-controlled electric heaters that maintained the same temperature gradient as encountered in engine operation. The lead-tin alloy was selected so that at this temperature it was in a plastic state to distribute the load as a fluid pressure over the interior of the combustion chamber, thereby simulating gas-explosion pressures. The aluminum lost strength because of the elevated temperature in the same proportion in the test as in engine operation. The setup is shown in Fig. 8.

As the machine can be set to shut off automatically shortly after failure starts, the heads could be inspected and rated much

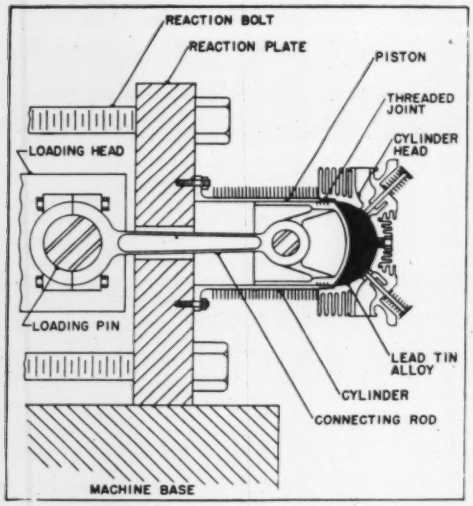

FIG. 8 SCHEMATIC DIAGRAM OF AIRCRAFT CYLINDER SETUP

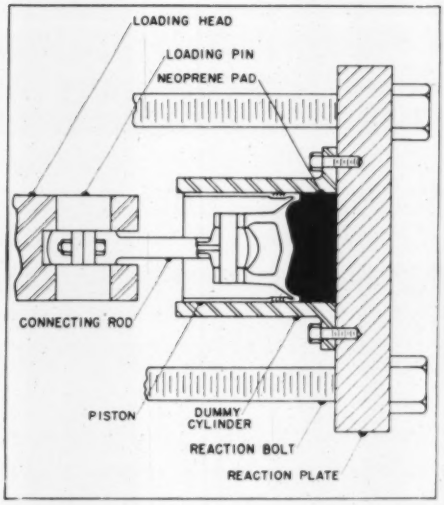

FIG. 9 SCHEMATIC DIAGRAM OF DIESEL PISTON SETUP

easier than if tested on an engine where failure would usually be disastrous.

TEST UNDER SIMPLE STRESS

When heat is not required, fluid pressures can be easily reproduced by using molded synthetic or natural rubber. For example, when testing the design of ferrous pistons, the arrangement shown in Fig. 9 is easily made. As in the previous case, a suitable alternating compressive force is applied to the connecting rod and the molded rubber produces a uniform pressure over the head. The simplicity of inspection, compared to engine installation and the use of overloads, gives rapid design evaluations.

STRESS RELATION IN COMPONENT PARTS OF AN ASSEMBLY

On the other hand, the setup can be complex if desired. Fig. 10 is a diagrammatic drawing of an arrangement which stresses the wrist pin, piston, cylinder head, cylinder block, crankcase, and crankshaft to a force corresponding to an explosion load caused by firing a combustible mixture. The compounding effects of distortion are present in such testing.

The weak spot in the original cylinder block was located in the same place as found on flight tests when the horsepower was increased. Further, a dynamic stress analysis could be made in the laboratory by applying SR-4 strain gages. When the proper measures were applied to the part to give improved life, the same result was found in the actual engine test.

The foregoing examples are related to automotive and aircraft components but they illustrate principles which should be applicable to most engineering elements.

CONCLUSION

In conclusion, the authors stated that full-scale testing in such fatigue-testing machines offers the following advantages for determining the optimum use of the metal: (1) Proper relationship of tension, compression, and torsion loads; (2) overloads; (3) simplification of instrumentation for dynamic stress analysis; (4) easy inspection for failure; and (5) correlation with service.

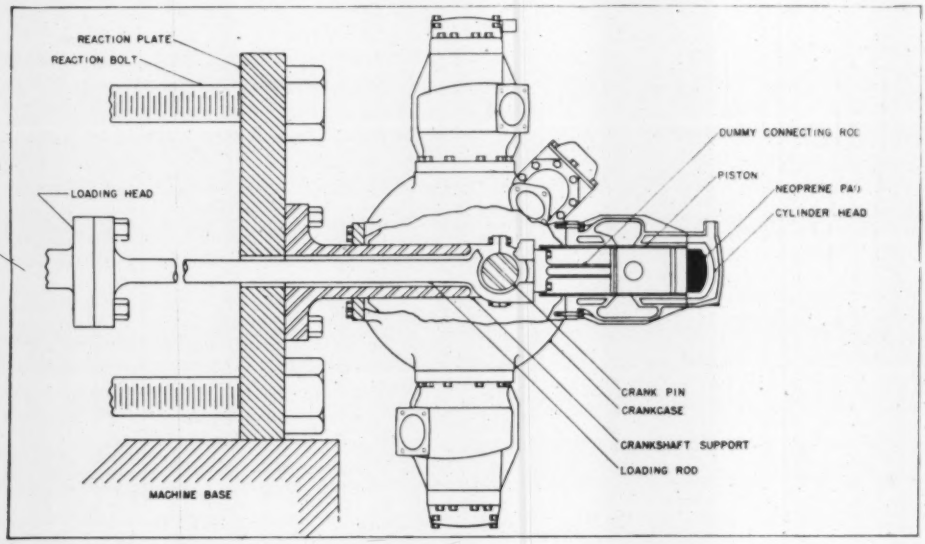

FIG. 10 SCHEMATIC DIAGRAM OF COMPLETE ENGINE SETUP

Electrostatic Painting

AN article by G. P. Kennedy, resident manager, Norge Division, Borg-Warner Corporation, Muskegon Heights, Mich., reveals that the Norge Division was the first in the refrigerator industry to adopt the Ransburg electrostatic spray process to the painting of cabinets and doors. The electrostatic spray unit, installed in the Muskegon Heights plant, automatically applies the first coat to the outside area of the refrigerator cabinet and doors.

The first cost records indicate that the conversion will save the company more than $100,000 per year in paint and labor. Production was increased 45 per cent with less floor space. The spray booth remains remarkably clean for the large volume of work processed, creating worth-while savings in maintenance costs. Additional economies due to lower ventilation requirements have also been realized.

The cabinets and doors are carried through a spray booth by an overhead conveyer. Two cabinets (one per hanger) on 48-in. centers are followed by a workholder designed to hold two sets of provision and machine-compartment doors. This permits the alternate painting of cabinets and doors in a way that best lends itself to the subsequent assembling operations. No change or adjustment in the automatic Ransburg equipment is required to coat both doors and cabinets. The cabinets are inverted to preclude dust settling on the top in the baking operation. The back is not coated in the first coat as this area is largely covered by the "flue" which is subsequently attached.

Spaced 12 in. from the surfaces being painted is the high-voltage grid which creates the electrostatic field of attraction between it and the electrically grounded parts. The high-voltage equipment and certain special controls were supplied by the Ransburg Electro-Coating Corporation. Among these controls is a new development called "the electronic spark guard," which turns the equipment off in case of any breakdown in insulation, or in case a part should inadvertently get so close to the voltage grid as to cause a spark. This device actually turns off the power before the spark occurs and thus adds considerably to the safety of the operation.

It is reported that the entire painting operation is accomplished with only seven automatic spray guns in one pass through the single booth, replacing six hand-spray men. These operate at very low pressures; 2 psi fluid pressure and 18 psi atomizing air pressure. By moving the guns automatically up and down the sides, and back and forth across the inverted top, a uniform paint film is deposited. This in itself is said to be a vast improvement over the erratic performance of hand-spray methods, and goes a long way toward elimination of paint rejects.

Hand spray is employed for coating the inside of the machine-compartment doors and the inside of the machine compartment itself, since these areas are shielded from electrostatic deposition.

A feature of the operation is the so-called "wrap around," inherent with the Ransburg process. Electrostatic attraction causes the paint to deposit as heavily on the edge masked from the spray direction as it does on the edge facing the spray direction. This is accomplished by the manner in which the spray guns are turned off and on between parts. At present, the length of time that the guns are operating is exactly the same for the 30-in-wide doors (and wider on large models) and for the 19-in. width on the sides of the cabinet. Norge engineers are now engaged in the installation of a switching arrangement which will permit individualizing the gun cutoff for the doors and the cabinets. It is anticipated that this will save an additional 10 or 15 per cent in paint consumption.

Another helpful factor provided by the wrap-around feature is the full coating that is accomplished on all edges. With previous manual spray the satisfactory coating of the edges was a most expensive operation in both paint and labor. If they were not properly coated there was possibility of rust starting there and creeping onto exposed surfaces.

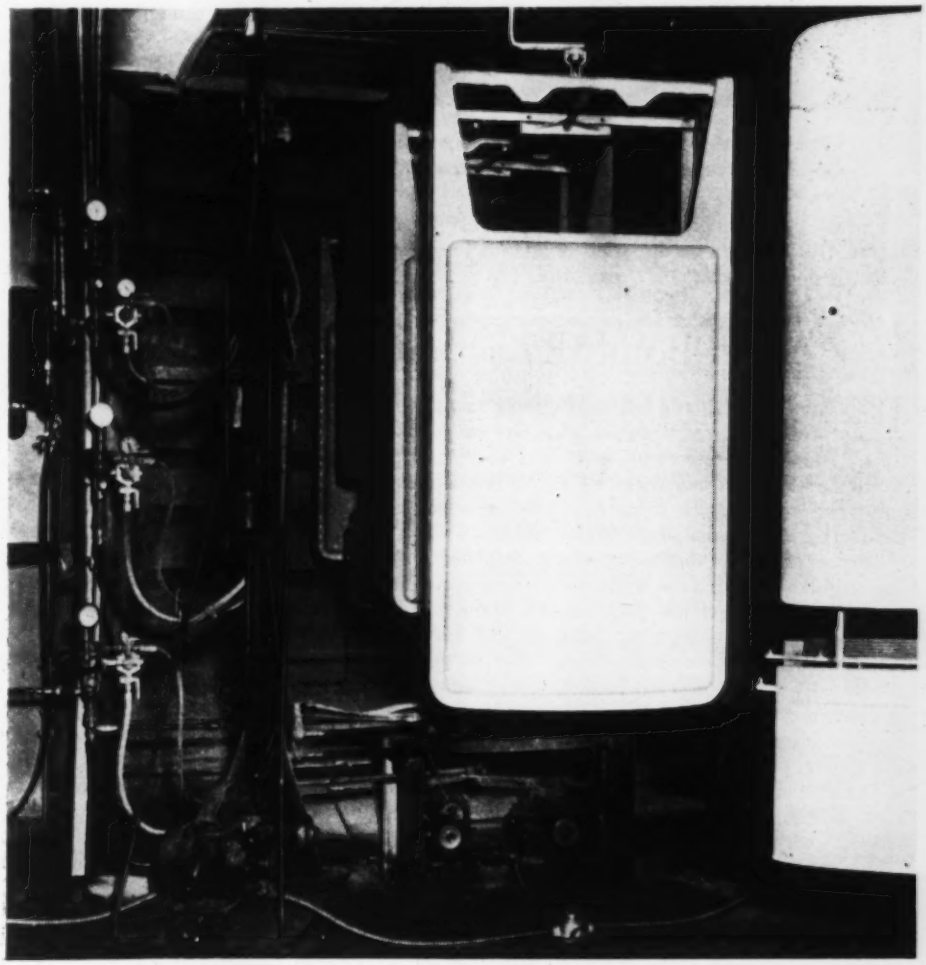

FIG. 11 OVER-ALL VIEW OF AUTOMATIC ELECTROSTATIC SPRAY INSTALLATION

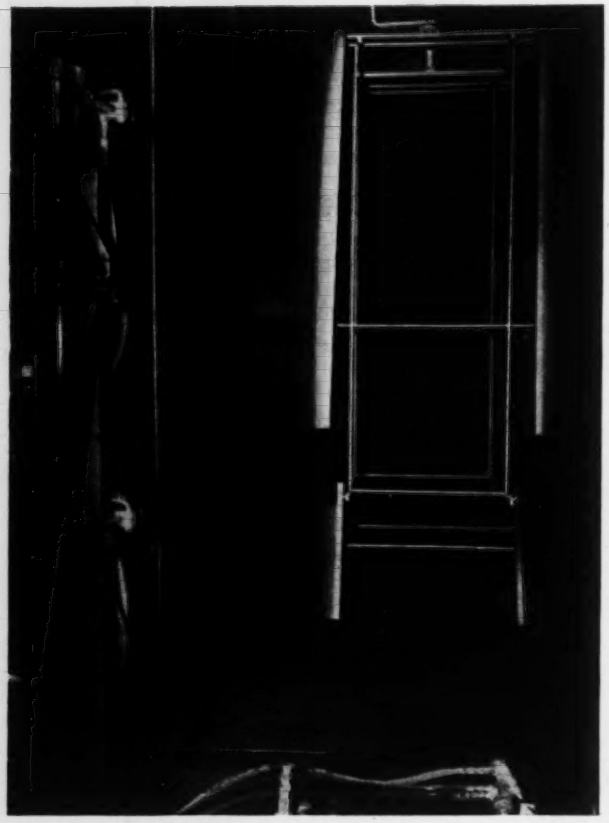

FIG. 12 CLOSE-UP OF ELECTROSTATIC SPRAY BOOTH SHOWS ARRANGEMENT OF THE THREE-SIDED ELECTRODE SYSTEM

The use of the Ransburg electrostatic spray process in the automotive field is also discussed in an article in MECHANICAL ENGINEERING, August, 1947, page 678.

Atom-Bomb Radiation

IF an atom bomb should fall on an American city, the population would be faced with the greatest emergency in its history. But it is by no means true that the entire population would be wiped out, nor that nothing could be done to help the survivors, according to Army Medical Corps officers who are conducting continuous study of the problem.

There is no known method of protecting those in the immediate neighborhood of an atom bomb when it explodes. Nevertheless, a great deal has been learned about mitigating the secondary effects of ionizing radiation and about protecting survivors who have received less than a lethal dose.

Many lives may be saved by widespread knowledge among physicians of therapeutic measures, and many more by a general understanding of preventive measures which can be taken by the general population.

The real difference between ordinary high explosives and atom bombs, it was pointed out, is the enormous amount of radiant energy produced by the latter—energy covering the whole range of wave lengths from heat waves to million-volt gamma waves.

The following four known kinds of penetrating radiation can be expected within the immediate area of a blast:

1 Gamma radiation. These 200,000,000-volt x rays are lethal to anyone within roughly a mile of the blast, do serious damage to those as close as a mile and a half, but their range is limited to approximately two miles. They move with the speed of light and most of them are produced at the instant of explosion.

2 Neutron beams. These streams of heavy atomic particles, shot out in all directions within a millionth of a second of the explosion, have slightly less range than gamma rays. Both pass through matter such as blood, bone, or flesh, produce extensive ionization of the atoms which make up body cells, which results in the breakdown of chemical bonds, causing profound alterations in cellular function. The fact that some kinds of cells, such as certain types of cancer cells, are affected more easily than others is the basis of radiation therapy. Whatever damage is done in this way is instantaneous, although observable symptoms may not appear for some time.

3 Beta rays. These are streams of electrons which rarely penetrate the skin and whose effects will be found chiefly on the surface.

4 Alpha particles. These are the nucleii of helium atoms, which do not get through the cornified, or horny tissue layer of the skin. Because of their low penetrating power it is not likely that either the beta rays or the alpha particles resulting directly from the explosion will cause fatal injury.

Army doctors say that there is not much even a medical man can do about the immediate radiation from an atom-bomb explosion. The immediate requirement will be for rescue work on a large scale and treatment for fractures, contusions, lacerations, and burns.

Also, aid may be given to victims of many sorts of secondary radiation from radioactive dust spread by the explosion, radioactivity caused by neutrons captured by atoms, or radioactive spray if the bomb is dropped in water. Against this various safeguards can be provided, and it is essential that physicians be trained in safety measures. Army, Navy, and Atomic Energy Commission scientists, as well as civilians interested in radiation therapy, are hard at work on the problem and substantial progress is being made. One important line of research is in the efficacy of blood transfusions, since it has been established that one of the most serious effects of radiation is damage to the blood-forming elements such as the bone marrow. A person tided over until normal function is resumed may be saved.

Most food in the affected area would be fit for consumption, but it would all have to be surveyed before it could be eaten safely. All the water in the region would probably contain radioactive isotopes, slow poison to anyone drinking it, but research is in progress on methods of removing radioactive substances. Decontamination of not only food and water but of refugees, by such means as complete change of clothing and thorough bathing would be necessary.

A series of intensive courses on the medical aspects of atomic explosion were instituted last May at the Army Medical Center, Washington, D. C. Nearly 700 doctors and scientists have been trained there in the fundamentals of radiation hazards, diagnosis, and treatment. More than 50 medical schools throughout the country have sent representatives, many of whom are now setting up similar courses in their respective institutions.

Besides flash burns, blisters similar to skin burns and sunburn are likely to appear on the skin of victims. In Japan, burns and blisters showed up within five minutes on those close to the explosion. At a mile away, they did not show for several hours, and at greater distances, up to two miles, the appearance of burns and blisters was delayed longer.

Immediately after a bomb blast those in the vicinity who escape immediate death from shock, burns, or falling debris may appear to have suffered no ill effects. But within a few hours,

victims seriously affected will feel nauseated and start to vomit. This may pass in a day or so. But at the beginning of about the second week when the hair starts to fall out, the feeling of general malaise experienced in the first few hours may return, accompanied by fever. There is likely to be bloody diarrhea, and examination will show that the white blood count has fallen to a low level. Death may come quickly, or there may be anemia and general debility over a long period, with eventual recovery.

Physicians must be prepared to take nothing for granted about the condition of the patient during the first few days, it was emphasized.

The threat of the atom bomb is, at least, now recognized and we have assembled a growing store of knowledge which can ultimately be mastered, Army Medical Corps officers have concluded.

Upper-Atmosphere Research

CAPTURED German V-2 rockets, which can carry a ton of equipment more than 100 miles up, have enormously increased our knowledge of the earth's outermost atmosphere. Several V-2's have been fired in New Mexico by the Army in a co-operative research program with a number of government and university laboratories. The results, published in technical reports, have been comprehensively reviewed by Ernst H. Krause of the Naval Research Laboratory, in a paper for the American Philosophical Society and are reported in the *Industrial Bulletin* of Arthur D. Little, Inc., April, 1948.

The V-2 is 46 ft long and 5 ft in diameter. To keep it pointed in the right direction, the propelling gases from the rocket motor play on carbon vanes located in the tail and controlled by gyroscopes. It rises slowly from the ground and goes faster and faster until it reaches a speed of about 3500 mph, when the fuel is exhausted. Thereafter the vanes cannot control the direction of flight and the rocket may roll, pitch, and yaw about, a serious disadvantage from the experimental viewpoint. On subsequent flights, the rocket will have a device to keep one instrument, the spectrograph, automatically pointed at the sun.

The rocket spends about five minutes above the 30-mile level, and some data taken at this time are radioed to the ground. To recover spectrographic and photographic data, the rocket is broken up—weakened by a small charge of TNT, it breaks on contact with the dense atmosphere—and the pieces tumble down relatively slowly. Even after extremely high flights, equipment often lands in fair condition and, occasionally, intact.

The present research concerns cosmic rays, the ionosphere, the spectrum of the sun, and measurements of pressure, temperature, and composition of the upper atmosphere. Much new and some totally unexpected information has been collected. Since cosmic rays change before they reach the earth, observation of primary rays has heretofore been impossible. The V-2 reaches the region of the primary rays and passes through the zone where the changes occur. This information will lead to a better understanding of what cosmic rays are and where they fit into the scheme of things.

Previously the radiant energy from the sun could be examined only at altitudes up to 20 miles. At 100 miles, wave lengths much shorter than those previously observed were found, but a layer of ozone lying between 20 and 40 miles absorbs these waves before they reach the earth.

Despite difficulties involved in dealing with the great variations of temperature and pressure found throughout the atmosphere, instruments for measuring these values were devised. At about 80 miles, pressures were recorded as low as one-ten-millionth of the atmospheric pressure on earth, corresponding to a high artificial vacuum. It is believed that beyond the measured range, at 100 miles, the pressure is about 100 times lower. Striking variations in temperature were noted. Temperature drops rather steadily with altitude until it reaches about —63 F at ten miles, and varies slowly for another ten miles. From 20 to 30 miles up, it increases steadily to 130 F, drops again to —100 F at about 50 miles, and finally rises again, reaching about 212 F at 75 miles.

On various flights, special strains of seeds and fruit flies were taken up 106 miles to determine whether radiation above the atmosphere might produce mutations. On recovery, they showed no detectible changes, but this is not conclusive, since the specimens were shielded by metal.

The next several years should see interesting developments in upper-atmosphere research, now that the groundwork and techniques have been perfected.

Malayan Tin Mining

THE rehabilitation of the Malayan tin-mining industry is proceeding steadily as materials and machinery flow into the country, according to the March, 1948, issue of *Tin and Its Uses*, a review issued by the Tin Research Institute, Fraser Road, Greenford, Middlesex, England. The damage to mining equipment during the Japanese occupation has been assessed at eight million pounds but the task of restoration has necessarily been hampered by the damage done to roads, railways, ports, and power stations. As in other spheres, the preliminary estimates of the speed of recovery have proved overoptimistic, but the steady work of restoration is now reflected in a satisfactory upswing of production.

More than half the Malayan prewar production came from dredges, the other half being derived from a large number of smaller enterprises including gravel pumping, hydraulics, open-cast mining, and so on. The total number of dredges installed in Malaya in 1940 was more than one hundred although the average number operating in 1937–1939 was only 81. The Malayan dredges include the largest tin-mining dredge in the world which is operated by Petaling Tin Ltd. Its pontoon is 304 ft long, 72 ft wide, and 14 ft 6 in. deep, and its power plant develops 1100 kw. The dredging buckets, which hold 20 cu ft each, can dig more than 130 ft below water level. But the modern tin dredge is much more than an excavating mechanism. The tin-bearing mud, as dredged, may contain only one part of tin ore in 8000 or even 10,000 parts of alluvial silt. By a complex system of screens and jigs this is sorted out mechanically on board the dredge until a concentrate carrying 35 per cent of tin ore is obtained. This is bagged and made ready for dispatch to the smelters.

By the end of September, 1947, 49 dredges had already been placed in service, although not all had reached normal working capacity. Of the smaller enterprises 390 were again at work compared with a prewar figure of about 800.

Though forecasting is difficult and dangerous, it is certain that 1948 will show a further large increase in output and rapid narrowing of the gap between supplies and demand. Economic factors will, however, have an important influence on the output since the relation of cost of production to selling price governs the productive capacity in tin, as in all other commodities. Production costs have increased in the Far East, as elsewhere, and heavy amortization costs of equipment, bought to replace wartime losses, have to be met. Modern mining methods have, however, extended the range of economic mining to ground of comparatively low tin content and the

proved reserves of the Malayan Peninsula are said to be sufficient to meet all demands for many years to come.

Protein Corrosion Inhibitor

CHROMATED protein coatings offering a convenient, inexpensive means of protecting metals—especially zinc, iron, brass, steel, and aluminum—during outdoor storage in mildly corrosive atmospheres, have been developed by Abner Brenner, Grace Riddell, and Robert Seegmiller of the National Bureau of Standards. The protective value of such films is somewhat better than that afforded by chemical surface treatments and is said to be much superior to that of corrosion-inhibited oils and waxes. The metallic surface to be coated is first dipped in casein, albumin, or gelatin; the resultant film is then impregnated with chromate, which both hardens the film and inhibits corrosion.

The principal constituents of the chromated protein films are a corrosion inhibitor for the metal, a protein which acts as a vehicle for the inhibitor, a hardening agent, and a bactericide to prevent putrefaction of the protein. The chromate always serves as the inhibitor and may act as the hardening agent and the bactericide as well. However, other materials such as formaldehyde, tannins, or certain salts of the heavy metals can be used as the hardening agent.

The four functioning constituents of the film can be applied in a single step or in several steps, according to the compatibility of the agents and the degree of protection desired. In the "two-step" process, which is usually the most satisfactory, the metal is first dipped into an aqueous protein solution. When the resulting protein film is dry, it is immersed in an acidified chromate solution for one half to three minutes and allowed to dry without rinsing. The preparation of the protein solution varies somewhat with each protein. Gelatin is dissolved in water by heating gently; albumin may be dissolved in water at room temperature by stirring; casein is dispersed in water and brought into solution with the addition of 25 ml of ammonium hydroxide per liter of solution. The chromate solution contains chromic acid (0.5 to 2 per cent) or a dichromate of zinc, iron, or nickel (1 to 10 per cent).

A simpler "one-step" method of forming the inhibiting film by a single immersion in a solution containing both the protein and the chromate has the disadvantage that the solution slowly deteriorates. A solution of this type is made by adding ammoniacal zinc chromate to a solution of casein. The resulting preparation should contain about 10 per cent of casein and the equivalent of about 5 per cent of zinc chromate.

The chromated protein films are yellow and, unless opaque pigments have been added, are transparent. Their flexibility and adhesion are said to be sufficient to prevent cracking or separation when the metal is bent. They are not injured by heating to 150 C, whereas most chromate films produced chemically on zinc lose much of their protective value at 100 C. Thickness depends principally on the concentration and viscosity of the protein solutions, varying with the type of protein up to about 0.0002 in. This is in contrast to the proprietary chromate films, which usually are not more than 0.00003 in. thick.

It is reported that when freshly prepared and hardened, the films are almost insoluble in water and are so hard that they cannot be scratched with the fingernail. Exposure to light further hardens some films and renders them still less soluble. However, the films may be quickly removed from metal parts by application of an alkaline solution such as 5 per cent sodium hydroxide. Their removal is thus more convenient and less hazardous than the removal of oil films with toxic or inflammable organic solvents.

The protein solutions, unlike the baths used for direct phosphate or chromate treatments, do not become exhausted and require replenishment, but are fairly stable for long periods. While chromated protein films are superior to direct phosphate or chromate coatings or to oil films for corrosion prevention, their life is less than that of suitable paint coatings. They are more effective on large regular surfaces than on the sharp edges and corners of small objects like nuts and bolts, where the film tends to pull away.

Uranium Search

THE United States Atomic Energy Commission recently announced a three-point program to stimulate the discovery and production of domestic uranium by private competitive enterprise.

The major elements of the program are as follows: (1) Government guaranteed ten-year minimum prices for domestic refined uranium, high-grade uranium ores, and mechanical concentrates; (2) a bonus of $10,000 for the discovery and production of high-grade uranium ores from new domestic deposits; and (3) government guaranteed three-year minimum prices for the low-grade carnotite and roscoelite-type uranium-vanadium ores of the Colorado plateau area, and government operation of two vanadium-uranium plants in that area.

John K. Gustafson, director, AEC division of raw materials describes the program as "an opportunity for prospectors and mining companies to participate in the nation's atomic energy industry by exercise of their own initiative and with the profit incentive. The interest and energies of individual prospectors, small operators, and large mining companies are now required in the production of source materials for atomic energy."

The AEC plans to continue and expand its own exploration, development, and research relative to raw materials. This work is designed to aid rather than limit the activities of private enterprise in prospecting, ore production, and ore beneficiation. Commission-sponsored diamond drilling and geological surveys in the Colorado Plateau area, and in other sections of continental United States and its territories, will cover private as well as public lands.

Information developed by the AEC concerning individual deposits will be made available to the owners of these deposits, but for security reasons may not be released for publication. In general, deposits of uranium discovered by the Commission on public lands are expected to be made available for development by private operators.

Uranium in deposits on the public lands, and other lands owned by the United States, is now reserved to the United States, subject to mineral rights established on or before August 1, 1946 (the date of the Atomic Energy Act). However, the Commission's guaranteed minimum prices have been made applicable to deliveries to it of ores containing such reserved uranium in consonance with the Commission's authority to pay fair and reasonable sums, including profits, for discovery, delivery, and other services performed with respect to such ores. The Commission wishes to encourage prospecting for new deposits of uranium ores on the public domain and has been advised by the Department of the Interior, which administers the disposition of the public lands, that valid locations may be staked on such deposits if the uranium occurs in a deposit which is valuable because of other minerals. In the unlikely event of the discovery of a deposit of uranium-bearing ore which does not contain some other valuable mineral, the Commission, upon notice, will take steps to protect the prospector's equity.

ASME TECHNICAL DIGEST

Substance in Brief of Papers Presented at ASME Meetings

Symposium on Flow and Fracture of Metals

THE following papers constitute part of a symposium on the flow and fracture of metals and are scheduled for presentation at the National Meeting of the ASME Applied Mechanics Division, Illinois Institute of Technology, Chicago, Ill., June 17–19, 1948. Digests of papers 48—APM-1 to 48—APM-14, also scheduled for this meeting, appeared in the May, 1948, issue of MECHANICAL ENGINEERING, pages 452 to 454. Advance copies of these papers are now available and may be purchased from ASME Publication-Sales Department, 29 West 39th Street, New York 18, N. Y.

Stress-Strain Relations for Finite Elastoplastic Deformations, by J. E. Dorn, University of California, and J. J. Latter, formerly University of California, Berkeley, Calif. 1948 ASME Applied Mechanics Division Meeting paper No. **48—APM-15** (in type; to be published in the *Journal of Applied Mechanics*).

The strains accompanying elastoplastic deformations are frequently so large that the simplified equations of the small-strain theory are invalid. Although several ways of describing finite strains are known, they are not readily adaptable to stress-strain analyses in elastoplastic materials. One of the difficulties arises from the failure of the laws of addition when the strains are defined in the conventional way. Another difficulty found from the observations is that the infinitesimal plastic strains, and not the finite strains, are related to the stresses. This analysis, which attempts to surmount these difficulties, is an extension of methods originally described in a paper on plastic flow in metals, to include elastic as well as plastic deformations.

The Interaction of Discontinuity Surfaces in Plastic Fields of Stress, by Alice Winzer and G. F. Carrier, Jun. ASME, Brown University, Providence, R. I. 1948 ASME Applied Mechanics Division Meeting paper No. **48—APM-16** (in type; to be published in the *Journal of Applied Mechanics*).

A fundamental solution for problems associated with discontinuity surfaces in the field of stress has been developed by W. Prager, but the accuracy with which it approximates the stress field obtained in actual materials under the same boundary conditions has not been established. In this paper a study is made of the limited case in which the discontinuity surfaces may intersect when they separate fields of constant stress. The results may be applied to more general intersecting fields.

The Propagation of Plasticity in Uni-Axial Compression, by M. P. White, University of Massachusetts, Amherst, Mass., and LeVan Griffis, Illinois Institute of Technology, Chicago, Ill. 1948 ASME Applied Mechanics Division Meeting paper No. **48—APM-17** (in type; to be published in the *Journal of Applied Mechanics*).

A theoretical investigation of the mechanism of uniaxial compression impact on elastic-plastic materials is described in this paper. The method of analysis is similar in some respects to that previously given for tension impact on such materials. It is concluded that four different kinds of behavior can occur, depending upon the impact velocity. In the lowest velocity range, the behavior in compression is similar to that found in tension. In this case stress and strain are propagated from the point of impact as a zone or wave front of ever-increasing length. This type of behavior ends at a velocity corresponding to the "critical" velocity found in tension impact. Within the next higher velocity range, stress and strain are propagated as a shock-type wave, or wave of very small length in which the transition from low to high stress and strain is very abrupt. At still higher impact velocities, there occurs "flowing deformation" in which the material is too weak to maintain coherency. Here there is a steady flow of the material toward and against the hammer, after which it flows in a thin sheet radially outward over the face of the hammer. The final possible state occurs at impact velocities greater than the speed of an elastic wave, so that no disturbance can escape from the hammer into the medium. Here the behavior is essentially that of a fluid, the impact force being independent of the strength of the material.

Discussion of the Forces Acting in Tension Impact Tests of Materials by D. S. Clark, Mem. ASME, and P. E. Duwez, California Institute of Technology, Pasadena, Calif. 1948 ASME Applied Mechanics Division Meeting paper No. **48—APM-18** (in type; to be published in the *Journal of Applied Mechanics*).

A method of measuring the forces acting on a specimen during a tension impact test is described briefly in this

Advance Digests

of papers to be presented at ASME meetings are included in this month's ASME Technical Digest. Premeeting copies of the complete papers are available and may be purchased from ASME Publication-Sales Department, 29 West 39th Street, New York 18, N. Y.

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Coupons may be used to purchase pamphlet copies of papers which will be presented at national meetings during 1948, including the 1947 Annual Meeting. (In ordering give title, author, and paper number. State number of copies wanted.)

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paper. In this method a dynamometer is used in tests made in rotary impact testing machine in which impact velocities up to approximately 200 fps can be attained. The method of computing force-time relations prevailing in a specimen subjected to tension impact is described from the standpoint of the theory of the propagation of elastic and plastic strain. The method is applied to a specific material to illustrate the computing procedure. A theoretical stress-time diagram has been computed for a specimen of SAE 1020 cold-rolled steel 0.300 in. diam and 8 in. long for an impact velocity of 150 fps. This computation has been made (*a*) on the basis that the dynamometer is rigid, and (*b*) on the basis of a dynamometer mounted in a manner approximately equivalent to that in the actual equipment. The diagrams are for the stress-time relations at the fixed end of the specimen. The computed curves are compared with an experimental force-time diagram obtained on the same material. The general shape of the experimental diagram is quite similar to the theoretical diagram computed on the basis of a nonrigid dynamometer.

The Influence of the Dimensional Factors on the Mode of Yielding and Fracture in Medium-Carbon Steel—I. The Geometry and Size of the Flat Tensile Bar, by Julius Miklowitz, University of Michigan, Ann Arbor, Mich. 1948 ASME Applied Mechanics Division Meeting paper No. **48—APM-19** (in type, to be published in the *Journal of Applied Mechanics*).

A detailed study of the local principal strains, during uniform straining in a flat tension bar, has proved valuable in explaining the large variations of the local necking strains, with uniform changes in geometry and size of the bar which were observed. An analogy has been brought out between the restraining action of the bar heads on the gage material, and that of the stagnant material of the neck on the flowing material adjacent to it. In both cases the magnitude of the restraining dimension is important, the degree of restraint increasing with an increase in dimension. The study in deformation is presented for both uniform straining and the complicated crosslike neck at fracture. The maximum strains in the neck increased when the bar size decreased. The maximum strain, in the lateral direction parallel to the bar width, became less, as the width-to-thickness ratio of the bar increased from 1 to 7. Beyond this value no effects were noted. The axial strain, calculated from the two lateral strains, reflected their trends.

Behavior of Steel Under Biaxial Stress as Determined by Tests on Tubes, by H. E. Davis and E. R. Parker, University of California, Berkeley, Calif. 1948 ASME Applied Mechanics Division Meeting paper No. **48—APM-20** (in type; to be published in the *Journal of Applied Mechanics*.)

The experimental work is described and results presented for tests on twelve $5^1/_4$-in-diam thin-walled tubes of low-carbon steel subjected to various conditions of biaxial stress. These experiments comprised the "pilot" series of tests in a larger investigation on the behavior of ship-plate steel under multiaxial stress conditions. The ductility of the metal under various biaxial stress conditions and at two temperatures, 70 F and —138 F, is reported. The evidence indicates that the metal is reasonably ductile, even at the low temperature, provided it is subjected only to a state of plane stress. If a state of triaxial stress is induced by restraint or by discontinuities in the material, the ductility may be greatly reduced at the low temperature. Evidence is presented to indicate that fracture may occur either by shear or by cleavage, depending upon the stress and temperature conditions. In a majority of cases, reasonable prediction of the stress-strain behavior of the metal in the plastic range can be made for various biaxial stress conditions from the data of the simple tension test, by use of the modified octahedral-shear concept.

Applied Mechanics

Centrifugal and Thermal Stresses in Rotating Disks, by W. R. Leopold, Jun. ASME, Wright Aeronautical Corporation, Wood-Ridge, N. J. 1948 ASME Semi-Annual Meeting paper No. **48—SA-1** (in type; to be published in the *Journal of Applied Mechanics*).

A general semigraphical method, a combination and continuation of the solutions indicated by Stodola and Timoshenko, was found by which the thermal and centrifugal stresses in a rotating disk of any arbitrary profile could be determined. This relatively simple and rapid method of solution requires for its application elementary arithmetic involved in the completion of a tabular form sheet, a temperature gradient along the radius of the disk, which may be approximated by an exponential function of the radius, and easily accommodates changes in the physical properties of the disk material at elevated temperatures. A disk profile and expected radial temperature gradient, as determined from heat-transfer analysis, were taken as an example, and the complete disk stresses calculated directly to demonstrate the use of the method.

The Manifold Problem, by J. D. Keller, Mem. ASME, Pittsburgh, Pa. 1948 ASME Semi-Annual Meeting paper No. **48—SA-2** (in type; to be published in the *Journal of Applied Mechanics*).

This paper deals with the general problem of manifolds supplying fluids to a set of parallel pipes or ducts, or discharging through numerous openings distributed along the manifold length. Examples are the familiar "pipe burner" for gaseous fuels; the manifold of the "radiant-fire" type of gas burner; headers or manifolds for certain types of multitube air heaters; the distributing flues above and below the checkers of open-hearth furnaces and of glass tanks; furnace combustion chambers containing heat ports; distributing pipes in water-filtering systems; and many others. The very specialized problem of the gasoline-engine manifold is not considered here.

Gyroscopic Effects on the Critical Speeds of Flexible Rotors. by R. B. Green, Cambridge, Mass. 1948 ASME Semi-Annual Meeting paper No. **48—SA-3** (in type; to be published in the *Journal of Applied Mechanics*).

The forces and moments on rotating disks are found for the general case, and the various possible criticals of common rotor systems are determined and plotted for all degrees of gyroscopic effect. Specific examples are shown of a cantilever system, two simply supported single-disk systems, a double-disk system, and an infinite-disk system. Methods of solution are indicated for any case. The gyroscopic effect is shown for all possible ratios of shaft rotating frequency to whirl frequency.

Three-Dimensional Solution for the Stress Concentration Around a Circular Hole in a Plate of Arbitrary Thickness, by E. Sternberg and M. A. Sadowsky, Illinois Institute of Technology, Chicago, Ill. To be presented at the 1948 ASME Applied Mechanics Division Meeting, Chicago, Ill., June 17–19, 1948. Paper No. **48—APM-21** (in type; to be published in the *Journal of Applied Mechanics*).

This paper contains an approximate three-dimensional solution for the stress distribution around a circular cylindrical

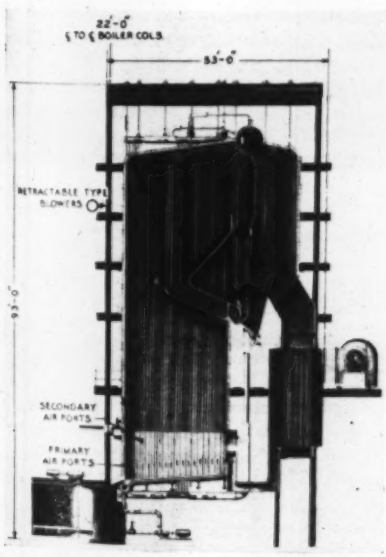
hole in an infinite plate of arbitrary thickness, which is otherwise in a uniform state of plane stress parallel to the bounding planes. The approach used rests on a modification of the Ritz method in the theory of elasticity. A knowledge of the triaxial characteristics of the ensuing stress concentration is held important in connection with modern views on failure. The results furthermore illuminate critically the significance of two-dimensional analysis in the problems of the type under consideration.

Fuels and Processes

Developments in Kraft-Process Recovery-Unit Design and Performance, by R. K. Allen, Jun. ASME, The Babcock & Wilcox Company, New York, N. Y. 1948 ASME Spring Meeting paper No. **48—S-2** (in type; to be published in Trans. ASME).

Greater capacity, economy, and reliability in operating service have been designed into the modern Kraft-process recovery unit during the past ten years by the development of new design features and the adaptation of sound engineering developments. By meeting the increasing demands for chemical recovery, and generation of power and process steam, the new units have kept pace with the progress of the paper industry.

Since 1937 unprecedented demand for paper products, coupled with the scarcity and high cost of labor, have stimulated developments in the design of B&W-Tomlinson recovery units which made possible increases in the capacity of individual units from 130 to 350 tons per day.



TWO-DRUM KRAFT-PROCESS RECOVERY-UNIT OF 275-TON PER DAY CAPACITY INSTALLED IN 1946

This paper discusses design features of a typical 275-ton per day capacity unit which was placed in service in 1946. This unit employs a large completely water-cooled furnace similar to that used in many large central-station power boilers. For protection, the tubes in the smelt zone in the lower portion of the furnace walls and the furnace floor are covered with chrome-ore refractory, anchored to the tubes by pin studs welded to the exposed face and sides of the tubes. The upper portion of the furnace walls and the boiler walls back as far as the rear of the superheater employ a bare-tube flat-stud construction for maximum heat transfer. The studs are welded to the sides of the tubes to form a continuous bare-metal wall surface.

Both the boiler and economizer are vertical-tube two-drum types. A tubular gas-air heater, employing parallel flow of gas and air, is included in this particular installation. The gas flows through the inside of the tubes and the air flows over the outside of the tubes making three passes, crossflow.

By changing the arrangement of the convection heat-absorbing surfaces, particularly the boiler screen and superheater, so that the resulting gas temperature and flow conditions substantially reduce the deposition of chemical solids deposited, a reduction in the man-power requirements for operation of the recent units has been achieved.

Because the chemical deposits are easier to remove and because the newer units have numerous cavities provided in the setting, successful application of mechanical soot blowers has eliminated the need for regular crews of men to do hand-lancing. Retractable-type soot blowers are used with two large nozzles at the end instead of the fixed-position, multinozzle, rotating units which in the past have not been satisfactory in the high-temperature zones.

The paper gives comparative performance data for a typical 130-ton per day plant of 1937 and the 275-ton per day plant of 1946 described in the paper. The economic factors affecting the recovery-system steam equipment are also discussed.

Utilizing Bagasse as Fuel, by F. X. Gilg, Mem. ASME, The Babcock & Wilcox Company, New York, N. Y. 1948 ASME Spring Meeting paper No. **48—S-3** (in type; to be published in Trans. ASME).

Bagasse is the fibrous residue of sugar cane which when shredded looks and feels like "excelsior." Although its moisture content fresh from the crushing rools varies between 45 and 55 per cent, bagasse is combustible and when properly burned can provide more than enough steam required to produce raw sugar and the power to drive sugar-mill equipment.

In the early days bagasse was sun-dried in the fields and shoveled into furnaces. Later it was found possible to burn the cane residue directly as it came from the mill in a Dutch-oven type of furnace using natural draft. Because grate maintenance was a constant source of difficulty, however, the hearth or grateless type of furnace was developed.

This furnace retained the feature of burning bagasse on the surface of the pile, but introduced combustion air horizontally through tuyères in the vertical walls surrounding the hearths.

Low boiler efficiencies, 50 to 60 per cent, resulting from the burning of wet bagasse as fuel, does not usually present a problem because most sugar mills have more bagasse than is needed. An excess of bagasse presents a real disposal problem, best solved by inefficient burning.

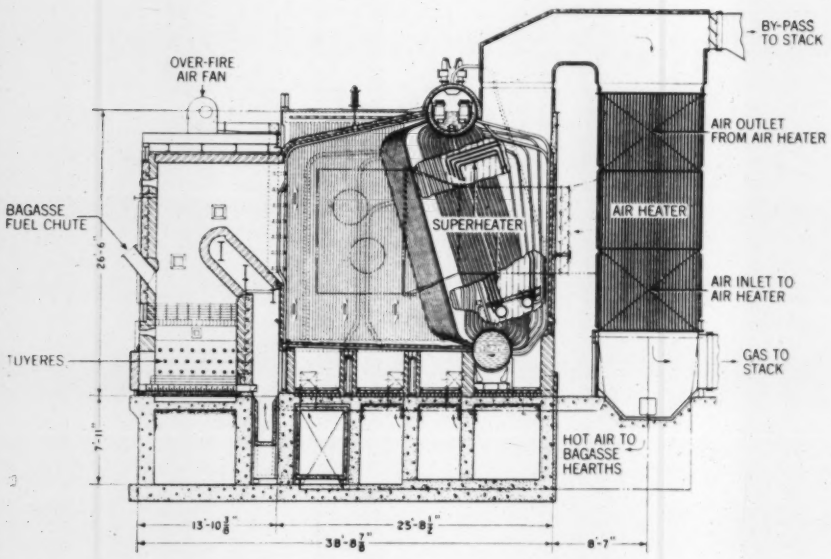
The Ward furnace for burning bagasse was developed to eliminate the costly refractory arches over the Dutch ovens. Because these furnaces can be cleaned in service, they can be operated continuously throughout the processing season. Since 1939 hundreds of Ward single-pass furnaces have been installed by the sugar industry.

In mills which refine their own sugar or which generate power in excess of that required in the mill, supplementary fuel such as oil or gas is used. An integral-furnace type of boiler with completely water-cooled walls and floor has been designed for firing bagasse, oil, and gas.

A typical unit of this kind installed in a sugar mill and starch plant in Florida is described. The unit is designed to operate at 650 psi and 725 F total temperature when generating 100,000 lb of steam per hr on oil or gas and 70,000 lb of steam per hr on bagasse.

In service for two years at high capacities, firing bagasse during the sugar-grinding season and oil during the off season, measured efficiencies of 83.3 per cent have been obtained with steam flow of 100,000 lb per hr.

The performance on bagasse was excellent and even exceeded the expectations in capacity. Combustion appeared to improve with higher burning rates because of higher furnace temperatures and greater turbulence. In tests run to determine the amount of refuse in the products of combustion leaving the unit at a steaming rate of 70,000 lb per hr, a value of less than 1 per cent of as-fired



WATER-COOLED INTEGRAL-FURNACE UNIT SHOWING WARD FURNACE FOR BURNING OF BAGASSE

fuel was obtained, representing a loss of efficiency of 0.7 per cent. A tabulation of test data is included.

While the predrying of bagasse has been considered economically unjustifiable in the past, the current critical situation of the world fuel supply may cause the sugar industry to utilize more of the Btu value of the fuel by removing some of its moisture before burning in the furnace.

Boiler efficiencies of about 80 per cent are possible when partially dried bagasse in pulverized form is burned with oil under the most economical conditions in a water-cooled integral furnace.

Gas-Turbine Power

The Gas Turbine as a Stationary Prime Mover, by L. N. Rowley, Mem. ASME, and B. G. A. Skrotzki, Mem. ASME, *Power*, McGraw-Hill Publishing Company, Inc., New York, N. Y. 1948 ASME Spring Meeting paper No. **48—S-5** (mimeographed).

About 15 of the 20 or more stationary gas turbines totaling over 100,000 kw now in operation or under construction may be classed as commercial units. These units use alloy materials on which extensive experience has been obtained and operate at the modest inlet temperature range of 1100 F with capacities varying from 1000 to 25,000 kw.

These facts indicate that the gas turbine has a definite place in the stationary power field. If its position is to continue to advance, however, an effort comparable to that now expended on technical developments must be direct to defining, evaluating, and exploiting its economic possibilities.

This paper presents some preliminary thinking along these lines. For cases where power generation is the sole requirement, several specific situations are analyzed. When considered within the limitations set, the examples serve to illustrate evaluation methods, reveal the influence of some important factors, and indicate certain broad areas in which gas-turbine possibilities lie. For cases where process heat as well as power must be applied, the economic problem is more complex. Here the general position of the gas turbine is indicated and some of the modifications that might enhance its usefulness are suggested.

Gas-turbine plants in the commercial-capacity range require about one third the building volume of a steam plant of equal capacity. These plants require less operating personnel and can be started from the cold position in 6 to 10 minutes. On the basis of limited experience, reliability and maintenance costs seems comparable.

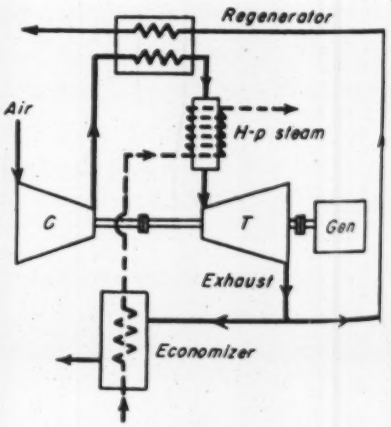
In considering the case for the isolated gas-turbine plant, designed solely for power purposes, a series of curves is presented to indicate how a gas-turbine plant of definite heat-rate characteristics compares with alternate steam and Diesel installations. Based on Swiss experience that a gas-turbine plant costs 85 per cent of a steam-turbine plant, it is concluded that the gas-turbine plant economically equals the steam-turbine plant at investments for the latter of: $58 per kw with 30 cents per million Btu fuel, $121 per kw with 40-cent fuel, or $184 per kw with 50-cent fuel. The break-even points in terms of Diesel investments for 50 per cent capacity factor are: $54 per kw with 30-cent fuel, $119 per kw with 40-cent fuel, and $189 per kw with 50-cent fuel.

From an analysis of a situation in which a gas turbine is used to extend an existing system as a peak-load or stand-by plant, it is concluded the application can be profitable only in a system operating at high levels of efficiency.

The results of a study of the application of a regenerative gas turbine as a base-load plant are presented in tabular form.

Because gas turbines operate without water and are quick-starting, they are admirably suited as transmission-line boosters. The financial advantages of installing a 10,000-kw plus a local peak-load 10,000-kw gas-turbine plant to serve a 20,000-kw peak-load demand having a 50 per cent load factor, as compared to a 20,000-kw transmission line, are shown to warrant serious consideration by transmission-line designers.

In industrial power applications where the plant must supply process heat in addition to power, the steam-turbine plant shows up best because of its versatility. The Diesel plants show up well only where the power demand is high in relation to the heat demand. From the exhaust-heat recovery standpoint, the gas-turbine plants are less flexible in design and operation than steam-turbine plants and not so well suited for high heat-power ratios, but are somewhat



GAS-TURBINE CYCLE, SHOWING GENERATION OF HIGH-PRESSURE STEAM AT HIGH-TEMPERATURE END OF GAS-TURBINE CYCLE WITH RECOVERY OF HEAT AT LOW END

more flexible than Diesel plants on both of these accounts.

An interesting possibility for the gas turbine is the production of high-pressure steam by introduction of heat-exchange equipment at the high-temperature end of the cycle. With forced circulation, superheated steam at virtually any pressure and temperature may be generated. A hookup in which generation of steam at the high-temperature end is combined with recovery of heat at the low-temperature end is also suggested.

While the application of the gas turbine as a prime mover in the stationary power field has been demonstrated in many fields, it has not been fully explored in others. Since possibilities of the gas turbine have been realized with units of conservative design, production of gas turbines on a commercial basis seems entirely justified today. Technical advances may be expected to widen the present limits on efficiency and use of fuels.

Gas-Turbine Power Plants for Operation With Low-Cost Fuel, by John Goldsbury, Mem. ASME, General Electric Company, Lynn, Mass. 1948 ASME Spring Meeting paper No. 48—S-6 (mimeographed).

This paper discusses the economics and general design requirements of gas-turbine power plants to be operated with low-cost fuel such as natural gas and crude oil in the oil fields, refinery by-products, and by-product gases from industrial processes.

In planning a gas-turbine power plant for operation with low-cost fuel, the basic considerations will be low first cost, reliability, convenience of operation, and compactness and weight. Fuel economy in itself will be of lesser importance. The results to date of certain studies which are being made to determine how a stationary gas-turbine power plant of moderate size, 2000 kw and less, can best be designed to meet these requirements, are presented.

Natural gas has been reported as available in large quantities in certain oil-field regions at a price of approximately 7 cents a thousand standard cubic feet for 1000-Btu gas. For calculations involving the properties of the fuel, natural gas with an assumed composition of 65 per cent methane and 35 per cent propane by weight has been used.

Since the decrease in air flow required as plant thermal efficiency increases tends to decrease the sizes of the turbine and compressor, the plant cost increment for increased efficiency is somewhat moderated. Devices for interstage cooling of compressors, interstage heating of turbines, and preheating of combustion air by the turbine exhaust gas can contribute greatly to power-plant efficiency, but the cost of such a device per unit of rating tends to increase with decrease in plant rating, while the fuel saving from a given increase in plant efficiency is a constant percentage regardless of rating. For this reason it will be more difficult to justify the use of such devices for the smaller ratings when the fuel price is low. As fuel price increases, the advantage of higher thermal efficiency increases till a point is reached where a heat exchanger is justified by the reduced overall fuel cost. For the same reason, it seems unlikely that closed-cycle plants will be economical for use with low-cost fuels except possibly in very large ratings. In this paper only the simple open-cycle power plant consisting of a compressor, one or more combustion chambers, a turbine, a generator, or other machine to absorb the useful output, and the necessary accessories is considered. The accessories will include a starter, and if a generator is to absorb the load, an exciter. They may also include one or more gears to permit each rotating element to run at optimum speed if the effects on first cost are favorable. Brief mention is made of the flow-type turbine power plant with preheated gas, which is a special case of the combustion-gas-turbine power plant, and approximate costs of these flow-type turbine power plants are given.

The following conclusions were drawn:

First cost rather than efficiency should be the primary consideration when a power plant is to be operated with low-cost fuel.

Compressor efficiency is less important than turbine efficiency, so that for the smaller ratings, at least, the centrifugal-type compressor should be considered.

The efficiency characteristic of the compressor used has a dominant effect on the selection of compressor discharge pressure.

The determination of optimum turbine inlet temperature must await further studies.

Water injection has an important favorable effect on power-plant first cost, but pure or treated water must be used to avoid injurious deposits on interior turbine surfaces.

The flow-type turbine power plant may well be considered when natural or process gas is available at suitable pressure. The output obtainable from a given flow of gas varies approximately with the absolute turbine inlet temperature, so that preheating of the gas may often be desirable.

How Gas Turbines Fit Into Future Power Patterns, by S. A. Tucker, Mem. ASME, *Electrical World*, McGraw-Hill Publishing Company, Inc., New York, N. Y. 1948 ASME Spring Meeting paper No. 48—S-8 (mimeographed).

This paper attempts to answer the following question: "When will the gas turbine really become a competitor of other prime movers, the steam turbine and the Diesel engine?"

According to the author, in one sense the gas turbine will not ever compete directly with other prime movers because it offers an entirely different set of characteristics and advantages. Almost every application so far achieved or contemplated has been based on some specific need that a gas turbine can fill to better advantage than steam, gasoline, or Diesel. The Houdry machines acting as superchargers, the jet-propulsion units for aircraft, the Velox boiler charging sets and stand-by units for desert service are examples of this difference.

Some immediate prospects are as follows: A gas-turbine locomotive should ride American rails in 1948, more in 1949; a ship-propulsion unit is ready for trials; data on several types of power units from Rumania, Switzerland, Peru, and Egypt will soon be available; there will be more data applying to power generation available from Schenectady and South Philadelphia.

Wherever oil or gas is a normal fuel, and for sizes between 2000 hp and 30,000 kw, gas turbines can compete with steam or Diesel on their own home grounds.

But the compelling factor has been the gas turbine's ability to meet needs not well handled by other prime movers. In aviation, one can fly faster with a gas turbine than any other heat engine. Dollars and cents, metal limitations, or fuel do not matter. To the Air Force speed is the one controlling objective.

The compactness of the gas turbine tempts railroad men. Getting 6000 to 8000 hp into a road locomotive using Diesels means several cabs, and steam is not a happy answer. Experience with Diesel and steam power plants for locomotives leads any railroad man to hope that the calculated performance of gas-turbine locomotives might prove a solution to the high-power high-speed road locomotive of the future.

Those who buy gas turbines in the next ten years will demand units of specific requirements with little real concern about price. Someday, it is hoped, manufacturing costs will be stabilized

with cost of gas turbines not out of competitive range.

Heat Transfer

A Mathematical Analysis of a Number of Dielectric Heating Problems, by Michael P. Heisler, Columbia University, N. Y. 1948 ASME Spring Meeting paper No. 48—S-9 (mimeographed).

The influence of various heating procedures upon the temperature-space-time history of a dielectrically heated slab is shown. The types of problems illustrated frequently occur in the dielectric bonding of wood laminates, in a number of ceramic or rubber heating and curing operations, and in the chemical industry.

The paper is based on calculations, and no direct experiments were carried out for the purpose of comparison. The results presented are mainly qualitative.

Upon a basic workpiece, a semi-infinite slab made of a homogeneous material whose thermal properties do not change with temperature, the following five different heating-up techniques are imposed and their results upon the temperature uniformity are analyzed:

1 Workpiece facing a hot platen. At the same instant that dielectric heating begins, the faces of the slab are brought into contact with a hot platen, so that heating-up occurs by the simultaneous action of a fixed elevated surface temperature and internal heat sources.

2 Switching and soaking. Initial heating up as in case 1, but after a given arbitrary time the dielectric unit is switched off and the workpiece is allowed to soak under the action of the fixed surface temperature.

3 Delayed hot-plate heating. The slab faces a cold platen of large heat capacity. The dielectric unit is turned on and heating up occurs everywhere within the slab except at the faces, which are kept at the temperature of the cold platens. After a given arbitrary time, the temperature of the platens is suddenly raised and maintained constant thereafter.

4 Thermal insulator placed between workpiece and the platen. In this case heat is generated in the workpiece, the insulator gaining heat by conduction only. (In order for no heat to be generated in the insulator the latter is placed between the electrode and the platen.)

5 Radiation-convection heat loss. The slab is allowed to cool freely in air while heat is being generated within it.

Equations are derived for each case and from these are developed charts which can be readily applied to engineering calculations.

All discussion centered on problems involving wood as the dielectric; however, the equations can be applied equally well to other dielectrics.

Although temperature uniformity has been stressed, in some cases, such as the bonding of thin thermoplastic sheets—a nonuniform distribution of temperature is absolutely essential.

The most desirable means of attaining a uniform temperature distribution is to raise the temperature of the plates at the same rate at which the center temperature is rising under the influence of dielectric heating.

One important fact brought out is that the best temperature uniformity is produced by the highest heating rate.

The equations and graphs presented hold for relatively short times only, that is, for values of Fourier's modulus equal to or less than 0.2.

Materials Handling

Industrial Truck-Handling Methods Applied to Production and Distribution, by C. F. Kells, Electric Industrial Truck Association, Long Island City, N. Y. 1948 ASME Spring Meeting paper No. 48—S-11 (mimeographed).

This paper discusses the application of storage-battery-powered, driver-ride type of industrial-truck systems of materials handling.

Certain types of industrial trucks have won more favor than other types, thus making it practical to classify industrial trucks into the following groups: The fork truck, low-lift and high-lift platform trucks, fixed-platform truck, and tractor. As a result of wartime experience and necessity for speed-up and expansion of distribution as well as production systems, fork-truck demand in 1947 was double that of all other types combined. It is largely responsible for the intensified interest in unit-load systems.

A unit load is a machine-size load that is made up of a number of man-size loads. To be most effective, some kind of a "handle" must be applied to or built into a unit load to permit pickup by the machine. The handles are most commonly those adapted to fork trucks, low-lift and high-lift platform trucks. Consequently the building of unit loads is the assembly of man-size loads into machine-size loads and equipping them with handles.

Handles may take the form of skids, strips of lumber or metal, slots built into the package or assemblies, pallets, and the like.

Twenty illustrations serve to typify the various applications of the industrial truck to the unit-load system. It is shown that unit-load systems fit production requirements as well as distribution and that the handles can be simple and inexpensive.

High-Temperature Piping

Some 1000-F Steampipe Materials, by Ernest L. Robinson, Mem. ASME, Turbine-Generator Engineering Division, General Electric Company, Schenectady, N. Y. 1947 ASME Annual Meeting paper No. 47—A-74 (mimeographed).

This paper presents long-time creep and rupture tests on molybdenum-vanadium pipe material in comparison with low chromium-molybdenum compositions. The molybdenum-vanadium composition shows superior long-time strength at high temperature. Furthermore, long-time soaking of molybdenum-vanadium piping material at high temperature has so far failed to show graphite formation.

The purpose of the paper is to present a series of test results contributing to available technical information on materials suitable for high-temperature steam piping. The group has been selected from results mostly unpublished and presented in a form suitable for guidance in design and for a basis of comparison between different compositions currently under discussion.

Creep strengths are both listed and plotted for a rate of 0.01 per cent per 1000 hr. Creep strengths for a rate of 0.001 per cent per 1000 hr are listed in tables. These strengths were determined by the General Electric "flow-rate" test which is a step-down relaxation-type test run with a total elastic-plus-plastic extension of 0.2 per cent. The so-called flow-rate test is usually run for 2000 to 3000 hr with one or more rates between the nominal values read from the log-log plot and tabulated.

Long-time rupture strengths are tabulated both for 10,000 and 100,000 hr but only the 100,000-hr strength is plotted. The longest test in each series is usually between 5000 and 10,000 hr. The 10,000-hr figure involves little extrapolation. The 100,000-hr figure is not free from uncertainty, and judgment is required in the selection of a suitable factor of safety. It must be kept in mind that breaks after a long time at high temperature are likely to be brittle in appearance with little elongation to give warning.

COMMENTS ON PAPERS

Including Letters From Readers on Miscellaneous Subjects

Synthetic Liquid Fuels

COMMENT BY FRED DENIG[1]

This paper[2] is a most timely presentation on the subject of synthetic liquid fuels. Some petroleum people have been assuring the public for many years that the supply of petroleum underneath the soil of the United States is practically inexhaustible, in spite of the fact that each oil field as it grows older has dropped off in production, and also in spite of the fact that, for every new field discovered, it means one less field to be discovered in the future. Thus America finds itself at the crossroads. The author indicates 30–50 per cent of the oil is unrecovered, the number of fields being discovered is declining, and the over-all reserve of oil and natural gas is declining with consumption. All of this, coupled with the fact that Americans are using more gasoline in their automobiles, more fuel oil to heat their homes, and more fuel oil to drive boiler plants, locomotives, and other heat-consuming media, spells disaster for this country unless something is rapidly done.

It is fortunate that the Bureau of Mines had the foresight and our Congress had enough gumption to back this foresight to set up an elaborate experimental program for the study of synthetic liquid fuels as one of the means of answering our future energy problem. However, it is to be regretted that the synthetic-liquid-fuel studies were the only ones authorized by Congress.

The writer believes that the electric-power fraternity should urge that Congress also authorize a substantial amount of money for the development of electricity for the purpose of driving automobiles and other moving vehicles. It is obvious that this commentator believes in coal-fired powerhouses. The electrification of railroads will solve partially the fuel-oil problem, as well as the smoke problem in so far as the railroads are concerned. The electric storage battery, properly developed, would answer the peak-load problem of the powerhouse; that is to say, mechanisms could be set up whereby batteries could be charged at off-peak hours, thus flattening out the power loads.

It is most interesting to compare figures on the various methods of converting coal to power or power equivalents. In his paper, the author gives an efficiency via the hydrogenation route of coal to gasoline of 38.3 per cent. This figure is believed to be high. The writer thinks it is closer to 29 per cent, unless the Bureau has developed some new techniques which it has not diclosed to the technical public. The Fischer-Tropsch process, based upon the author's figures, will have a thermal efficiency of 33.4 per cent, whereas the latest electric power plants require about 10,000 Btu in the form of coal per kwhr, giving an efficiency of 34 per cent. The utilization of power from a battery to a vehicle is far more efficient than the utilization of gasoline in a moving vehicle.

COMMENT BY R. F. MARSCHNER[3]

The author's clear exposition has hinted at an important point which, had he wished to lengthen his paper, might well have been elaborated, namely, that elements of collaboration between the several synthetic-fuel processes are appearing.

Natural gas is hydrogen-rich, as compared to petroleum, and either shale oil, or especially coal, are hydrogen-poor; consequently, there is a logical interdependence of synthetic-oil processes among themselves. In synthesis from natural gas, the first of the supposedly alternative Fischer-Tropsch reactions

$$CO + 2\,H_2 \rightarrow H_2O + (CH_2)_x$$
$$3CO + 3\,H_2 \rightarrow H_2O + (CH_2)_x + CO_2$$

is preferable because of the loss of a one third of the valuable carbon as carbon dioxide in the second. But in the Fischer-Tropsch synthesis from carbon-rich coal, the second reaction has some advantage over the first. Developments in Fischer-Tropsch catalysts may make either of these reactions relatively more attractive. One half the cost of coal hydrogenation lies in hydrogen production, and as the author further points out, some hydrogen can be supplied from the excess in natural gas. Light hydrogenation of shale oil could also be accomplished in a similar way. Products from natural gas and coal have been utilized together with advantage. The excellent cetane number and undesirably high pour point of Fischer-Tropsch Diesel oil complement the poor cetane number but low pour point of coal-hydrogenation distillate. Quality problems arising from the unsaturated character of shale-derived fuels may be solved in part by experience with olefinic Fischer-Tropsch products from natural gas or coal.

Predictions are beyond the scope of the paper, but the facts permit a convincing conclusion that the several synthetic-oil processes can no longer be considered entirely separately.

COMMENT BY MURPHREE[4]

The author has given an excellent general review of the information available on production of synthetic fuels and has also pointed out the reasons for the possible need for such fuels in the future.

In commenting on the oil supplies, the paper brings out that present reserves are of the order of 21 billion barrels and that, for the last several years, discoveries of new oil supplies and extensions of existing discoveries have about kept in balance with consumption. The paper points out that most of the additions have come from extension of known reserves rather than new discoveries. This statement may give a somewhat distorted picture since, with time there are normally extensions in the estimated reserves which have been based upon new discoveries, and this extension will undoubtedly apply to discoveries within the last few years just as much as it has applied to discoveries in former years. Many people in the oil business feel that it will be possible to maintain reserves at the present level but that, for current supplies, it will be necessary to depend more upon imported oil, particularly from South America.

[1] Vice-President and manager, Research Department, Koppers Company, Inc., Pittsburgh, Pa. Mem. ASME.

[2] "Synthetic Liquid Fuels in the United States," by W. C. Schroeder, MECHANICAL ENGINEERING, vol. 69, Dec., 1947, pp. 989–995.

[3] Research Department, Standard Oil Company (Indiana), Whiting, Ind.

[4] President, Standard Oil Development Company, New York, N. Y.

The technical information presented in the paper on the different synthetic-fuel processes, in general, is in reasonable agreement with information available to the writer. In the case of the Fischer-Tropsch operation, using an iron catalyst, under suitable operating conditions a quite olefinic product can be produced, which is not clearly brought out in the paper. The water requirements for production of synthetic fuels from natural gas appear somewhat high, and the quantity of natural gas required for the special case of coal hydrogenation appears low. The picture on production of oil from shale may be somewhat misleading in that the requirements for water given in the paper cover only the retorting of shale to give a material somewhat comparable to crude oil. To produce products from this synthetic crude oil of a quality which can be marketed under normal conditions, considerably further refining would be required, and this refining will be more difficult in general than is the case for crude oil.

AUTHOR'S CLOSURE

The discussion submitted on the paper, "Synthetic Liquid Fuels in the United States" covers a number of important points that were not fully developed in the paper. The author appreciates the assistance of the discussers in filling in these gaps. Lack of exact figures for some of the requirements for the plants still results in certain disagreements, but these can be eliminated through the extensive research now being carried on in this field by industry and the government.

Mr. Denig points to the need for lifting some of the load from our petroleum resources through the substitution of coal for oil for combustion purposes, and increased use of electricity from hydroelectric and coal-fired powerhouses, including possible application to moving vehicles. Substitution of coal for oil which is being burned under industrial boilers is a quick and direct means of saving considerable quantities of liquid fuels. Similar substitution for domestic heating will probably be much more difficult to bring about, and perhaps less advantageous in view of the human effort involved in handling small lots of house-heating fuel at the mines, by the railroads, by the distributors and retail dealers, by the householder, including the final disposal of the ashes. Each of these steps involves an important amount of hand labor which can largely be eliminated by furnishing the domestic users a liquid or gaseous fuel made, if need be, from coal at the mouth of the mine.

Mr. Marschner's views on the interdependence of the various synthetic fuel processes are very important and are all too frequently overlooked. There seems to be a strong tendency to consider the processes as competitive rather than complementary, which leads to the idea that one process or raw material will dominate the synthetic field. From the involved technologic, geographic, and economic factors concerned in the development of the synthetic-fuels industry, it is almost certain that this cannot be the final result. It is for this reason that the Bureau of Mines program has not been centered on one process or one raw material, but has instead attempted to develop a broad picture of the entire field.

Mr. Murphree indicates a number of important points with respect to reserves and discoveries that were not fully treated in the paper. Since this article was written (about nine months ago), the petroleum picture, in so far as civilian consumption is concerned, has become somewhat clearer. With a strong exploration program, and assuming that some of the country's major producing fields do not taper off more quickly than anticipated, it seems reasonable to believe that a petroleum production around 5 million barrels a day can be held for several years. It is now predicted that total demand will reach 6 million barrels a day in 1948 (instead of 1951 as predicted in the paper) and probably will reach 7 million barrels a day by 1953 or 1954. This will leave a gap of 2 million barrels a day which must somehow be filled to meet our normal civilian requirements to say nothing of emergency or war demands. Synthetic fuels can supply part of this 2 million barrels a day, but only if immediate steps are taken to start commercial operations. In eight to ten years the industry could be built up to supply the full amount and more if necessary. The important point at the moment is to see that a commercial synthetic-fuel industry is started as promptly as possible.

W. C. SCHROEDER.[5]

[5] Chief, Office of Synthetic Liquid Fuels, Bureau of Mines, Washington, D. C. Mem. ASME.

ASME BOILER CODE

Interpretations

THE Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Anyone desiring information on the application of the Code may communicate with the Committee Secretary, ASME, 29 West 39th St., New York 18, N. Y.

The procedure of the Committee in handling the Cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are then sent by the Secretary of the Committee to all members of the Committee. The interpretation, in the form of a reply, is then prepared by the Committee and is passed upon at a regular meeting.

This interpretation is later submitted to the Council of The American Society of Mechanical Engineers for approval after which it is issued to the inquirer and published in MECHANICAL ENGINEERING.

Following is a record of the interpretations of this Committee formulated at the meeting of April 2, 1948, and approved by the Council on May 3, 1948.

CASE NO. 724

(Annulled)

CASE NO. 1063

(Interpretation of Par. H-83)

Inquiry: May welded stays be installed in low-pressure steel heating boilers without the countersinking now required by Par. H-83? If so, what rules will govern the installation?

Reply: Staybolts, diagonal stays, and through stays may be installed in low-pressure steel heating boilers under the following requirements:

(1) The stays shall be inserted into holes through the sheets except as provided in (3) and the area of the weld in shear, measured parallel to that portion of the stay extended through the sheet shall be not less than 1.25 times the required cross-sectional area of the stay. The size of the filled weld attaching the stay to the sheet shall be not less than the thickness of the plate being stayed for plates up to and including $^3/_8$ in. in thickness and for thicker plates the size of the fillet weld need not exceed $^3/_8$ in.

(2) The ends of stays inserted through the sheet shall not project more than $^3/_8$ in. beyond the surfaces exposed to products of combustion;

(3) Diagonal stays may be attached to the inner surface of the shell, but not the head, by fillet welds only, provided:

(*a*) The size of the welds is not less than the shell plate thickness but need not exceed 3/8 in.;

(*b*) The cross-sectional area of the portion of the stay welded to the shell and also the cross-sectional area of the fillet welds parallel to the axis of the shell, measured at the throat, are not less than 1.25 times the required cross-sectional area of the stay, and further provided that such fillet welds shall continue the full length of the side of that part of the stay in contact with the shell.

4 The longitudinal centerline of the stay (projected if necessary) shall intersect the inner surface of the plate to which the stay is attached within the outer boundaries of the attaching welds (also projected if necessary).

5 The welding shall be done in such a manner that excessive weld deposits do not project through the surface of the plate at the root of the weld.

CASE No. 1069

(*Interpretation of Specification SA-217*)

Inquiry: Is it permissible to use the new Grades WC5 and WC9 provided in ASTM Specifications A 217-47 T under Specification SA-217 of the Code?

Reply: It is the opinion of the Committee that Grades WC5 and WC9 may be used under Specification SA-217 of the Code provided that such provisions for these compositions as are provided in ASTM A 217-47T are followed, and that in all cases the minimum draw temperature shall be not less than 100 F above the contemplated operating temperature. The permissible stresses for these grades shall be as follows:

	Temperature deg F				
Grades	—20 to 650	700	750	800	850
WC5	15000	15000	15000	14000	1250
	900	950	1000	1050	1100
WC5	10200	8250	6250	...	...
	—20 to 650	700	750	800	850
WC9	12000	15000	15000	14000	12500
	900	950	1000	1050	1100
WC9	1000	8250	6250	4800	3700

Proposed Revisions and Addenda to Suggested Rules for the Care of Power Boilers, Section VII of ASME Boiler Construction Code

THE Suggested Rules for the Care of Power Boilers was compiled in 1926 and pertains only to boilers with steam pressures up to 250 lb and without superheat. Modern boilers and practices make it mandatory to rewrite these rules and to include rules for boilers having higher pressures and superheat.

The Appendix, containing rules for the analysis, treatment, and method of feedwater, has been rewritten and includes all rules relating to chemistry used in the care of boilers. The revision of the rules relating to the mechanical section will be presented later.

These proposed rules have been formulated by a special committee of 20 outstanding authorities on the subject representing all parties affected by this Code (under the jurisdiction of the Feedwater Committee of the Subcommittee of the Boiler Code Committee on the Rules for Care of Power Boilers). This work was under the direction of C. W. Rice, Chairman, and Dr. E. P. Partridge, Chairman of the Work Committee.

The proposed rules relating to chemical treatment are presented here in tentative form for the purpose of securing the widest possible discussion upon the subject before final adoption. Everyone interested in these rules is urged to submit discussion before October 1, 1948.

It is to be noted that a proposed revision of the Code should not be considered final until formally adopted by the Council of the Society and issued as pink-colored addenda sheets. Communications should be addressed to the Secretary of the Boiler Code Committee, 29 West 39th St., New York 18, N. Y., in order that they may be presented to the Committee for consideration.

SUGGESTED RULES FOR CARE OF POWER BOILERS PART B

1 The following material pertinent to the control of chemical conditions within steam boilers to promote safety in operation is organized under six general headings as follows: Cleaning out and laying up boilers, scale, sludge and oil, corrosion, embrittlement, foaming and carryover, sampling, testing, and reporting of analyses of water and steam samples.

2 In each case an attempt has been made to state in simple, explicit, and concise form the problems, the characteristics by which they may be recognized, and the principles by which they may be corrected. It is recommended, however, that the control of boiler-water conditions be established and supervised by personnel specially qualified by training and experience in this highly technical field.

CLEANING OUT AND LAYING UP BOILERS

3 **Cleaning Out New Boilers.** Upon erection, a new boiler should be reasonably free from mill scale, corrosion products, and other foreign matter.

4 Before placing a new boiler in service, it should be cleaned thoroughly in order to remove grease and other organic matter, rust and remaining mill scale, protective coatings applied by the manufacturer to prevent atmospheric corrosion, welding flux and all other foreign matter normally incident to fabrication and erection.

5 The objective to be attained in cleaning out a new boiler is to produce a clean metal surface on all parts of the boiler which contact water or steam during operation. All water-soluble materials, fatty acids, oils and greases, mill scale, rust, paint and similar materials should be removed. The solution employed should be a good cleaning agent for these purposes.

6 ALKALI CLEANING. This operation is conducted with alkaline detergent solution to remove all foreign material from the internal surfaces of the boiler, economizer and superheater. This operation should be conducted only under the supervision of personnel specially qualified by training and experience.

7 ACID CLEANING. This operation is conducted with inhibited acid solution primarily for the purpose of removing mill scale and products of corrosion. This operation should be conducted only under the supervision of personnel specially qualified by training and experience.

8 **Cleaning of Boilers After Service.** These instructions apply to a boiler which is taken out of service for cleaning, or for major repairs and cleaning, preparatory to being placed back in service or preparatory to being placed in either wet or dry storage.

(*a*) When a boiler is found to be scaled or corroded, it should be cleaned internally before being placed back in service;

(*b*) When a boiler is taken out of service for major repair, it should be clean internally before being placed back in service;

(*c*) When a boiler is to be placed in wet or dry storage for an appreciable length of time, it should be internally cleaned.

9 INTERNAL CHEMICAL CLEANING. The purpose of this operation is to remove scale, mill scale, and corrosion products not removable by simple washing or mechanical meth-

ods. Two types of chemical cleaning are applicable—acid washing and alkali washing. The decision as to the type of cleaning to be employed and the supervision of the cleaning procedure should be by qualified personnel.

10 Laying Up Boilers Out of Service. When a boiler is taken out of service, the boiler should be cooled until the water is below the atmospheric boiling point, the boiler should be emptied and flushed out, and an inspection should be made to determine what repair work is necessary and what mechanical and chemical cleaning should be done. A decision should then be made on whether to employ dry storage or wet storage.

11 DRY STORAGE. This procedure is preferable when boilers are out of service for extended periods of time or in locations where freezing temperatures may be expected during standby; and for reheaters.

(*a*) The cleaned boiler should be emptied and thoroughly dried. Any moisture left on the metal surface would cause corrosion to occur on long standing. Precautions should be taken to preclude entry of moisture in any form, from steam lines, feed lines, or air;

(*b*) Trays of a moisture-absorbing material, such as quicklime, may be placed inside the drums to absorb the moisture from the air;

(*c*) Economizer, superheater, and reheater sections should be placed in dry storage similarly to the boiler proper, whenever practicable, and, in all cases, left tightly closed to the outside atmosphere and with liberal free opening to the dry space in the boiler.

12 WET STORAGE. This procedure is preferable when boilers are to be placed in standby condition for short periods of time or when it is likely that a standby boiler will be needed for service in a hurry. The procedure should not be employed for reheaters nor for boilers in locations where freezing temperatures may be expected during standby.

(*a*) The cleaned boiler should be emptied and several strips of bright, clean boiler steel should be suspended at different locations within the boiler to serve as test specimens;

(*b*) The boiler should then be closed and filled with feedwater to the top and throughout the superheater. Caustic soda to maintain a prescribed caustic alkalinity in the water and an oxygen scavenger such as sodium sulphite should be added along with the feedwater in order to minimize corrosion during standby. Water pressure greater than that of the atmosphere should be maintained within the boiler;

(*c*) Frequent water samples should be colleced and tested for residual alkalinity and oxygen scavenger. At intervals of about one month, the water level should be lowered by blowing down, the boiler opened, and the test strips examined for corrosion. The boiler is refilled with feedwater with addition of required make-up chemicals.

SCALE, SLUDGE, AND OIL

13 Solid material found on the internal surfaces of a boiler after operation may include both scale and sludge.

14 Scale. Scale is a deposit formed from solution directly in place upon a surface. It may or may not adhere to the underlying surface, is usually crystalline and dense, frequently laminated, and occasionally columnar in structure. Scale results from concentration of many natural waters in the absence of constituents favorable to the formation of sludge. Under certain conditions, substances which normally form sludge may deposit in a dense adherent form.

15 Scale is objectionable because it may lead to overheating of the steel surface on which it forms, with resultant bulging or actual failure.

16 The prevention of scale usually requires the administration of proper chemical treatment to the feedwater, which may be external or internal to the boilers, or both.

17 The selection of the proper chemical treatment, which necessitates an exact knowledge of the existing environment of the individual plant, should be made by a chemist, chemical engineer, or other individual specially qualified by training and experience in the conditioning of water for use in boilers.

18 The chemical treatment selected, internal or external, should be regulated by means of periodic analyses of samples of such waters from the system as are necessary for maintaining scale-free evaporating surfaces.

19 The kind and frequency of such control tests or analyses will be a function of the type of treatment, the specific character of the water, and the physical environment of each individual plant. No general limits for alkalinity, total dissolved solids, phosphate, sulphate, or other constituents of the water can be indicated for universal application.

20 The removal of scale, by either chemical or mechanical methods, should be accomplished with caution in order to minimize immediate or future damage to the boiler or the personnel.

21 The use of either alkaline or acid chemicals for the quick removal of scale should be supervised by personnel specially qualified by training and experience.

22 If mechanical cleaning is resorted to, the loss of boiler metal should be avoided as much as possible.

23 Sludge. Sludge is a water-formed sedimentary deposit. Usually it comprises soft and generally non-adherent deposits formed by precipitation from the concentrating boiler water, but it may include all suspended solids carried by the water. Sludge usually does not cohere sufficiently to retain its physical shape when mechanical means are used to remove it from the surface on which it deposits, but it may be baked in place and be hard and adherent. Sludge usually will not deposit on the evaporating surfaces in sufficient thickness to cause serious overheating.

24 The maintenance of sludge in a favorable nonadherent state can be effected by means of proper water treatment. Its accumulation should be regulated by the blowdown control best suited for each individual plant. It is advisable to remove loose and adherent sludge by washing as soon as possible after removing the boiler from service.

25 Oil. Oil in the concentrating boiler water, particularly in conjunction with sludge, may impair heat transfer to such an extent that excessive tube losses may result. Oil may also cause excessive entrainment of boiler water in the steam.

26 It is very important that the entry of oil into the feedwater should be avoided. When it is necessary to remove oil and combined deposits from an opened boiler, a suitable cleaning agent should be used.

CORROSION

27 Corrosion Within the Boiler and Superheater. In the absence of boiler scale, the eventual life of drum metal, boiler tubes, and superheaters is usually dependent on the depth of localized pitting, or the thinning of the shell or tube wall by general corrosion.

28 Pits of relatively large area, not covered by tubercles, may be produced by free mineral acid in the boiler water. When mill scale or adherent boiler scale covers steel only incompletely, pitting may occur in the areas of metal exposed to the water.

29 Pitting of steel in contact with neutral or alkaline water results in the formation of a tubercle of red or black iron oxide over each small area where corrosion is proceeding.

30 In general, the corrosion reaction is accelerated by increase in the following: concentration of dissolved oxygen, temperature, electrical conductivity of the boiler salines and concentration of hydrogen ion (corresponding to a decrease in *pH* value).

31 Localized excessive concentration of alkaline constituents of boiler water in contact with steel particularly in regions of high heat input or poor circulation may produce chemical attack, in the form of irregular pitting or regular grooving of the tube wall. This type of attack is observed most frequently in horizontal or slightly inclined tubes, but may develop even in vertical tubes. Similar corrosion may be produced, though less rapidly, by water of neutral character. The end products of this corrosion attack are magnetic oxide of iron, sometimes adherent, and hydrogen gas.

32 Attack on the inner surface of superheater tube metal is usually the result of the reaction of steam or heated metal. Carryover and concentration of drops of boiler water on the metal surface may increase the rate of corrosion. Magnetic oxide of iron is readily formed, accompanied by the evolution of hydrogen gas.

33 Lubricating oil, when carried into the boiler, frequently acts as an insulating medium on the boiler tubes; thus, oil, as well as the presence of adherent mineral scales, may permit the overheating of metal to produce corrosion results somewhat analogous to that produced in the superheater tubing. The substances present in adherent scale may react with the steel in severely overheated tube areas.

34 The bagging and rupturing of boiler tubes and superheater tubes is not always preceded by appreciable corrosion, but may result from simple overheating of the metal walls.

35 **Destruction of Metals Ahead of and Beyond the Boiler.** The two principal factors contributing to the destruction of metals in the steam and water cycle ahead of and beyond the boiler are mechanical attack or erosion, and chemical attack or corrosion. Cavitation (an aggravated form of erosion) accompanied by corrosion, contributes to the loss of metal in the impellers and casings of centrifugal pumps, and in the inlet ends of heat-exchanger tubes. Steam impingement on the tubing in heat exchangers, and on the turbine blades and buckets and on upper rows of condenser tubes, particularly when accompanied by finely divided liquid or solid particles, erodes the metal parts and the products may find their way into the boiler. The erosion may be accompanied by corrosion.

36 The principal chemical factors that produce corrosion in the piping and apparatus ahead of and beyond the boiler are dissolved gases and free mineral acids. High concentrations of alkalies may also contribute to corrosion of certain apparatus using non-ferrous alloys. Pitting (a local attack on the metal) when produced by oxygen is usually found covered by the oxidation products of the corrosion reactions in the form of tubercles. Attack of steam condensate lines, traps, and drains by carbon dioxide is noted by the grooving of the metal below the water line, and the absence of corrosion products within the corroded areas. The attack of free mineral acids, including hydrogen sulphide, may be noted by the appearance of relatively large areas of pitted surfaces, tubercles being absent. High concentrations of alkalies in the water may affect non-ferrous metals and alloys particularly those of the boiler feed pumps.

37 Ammonia evolved in the boiler does not react with the ferrous metals within the operating temperature and pressure ranges in the steam cycle. Ammonia dissolved in steam condensate may attack non-ferrous metals. Hydrogen gas, the presence of which is more conspicuous in the high pressure and high temperature installations, does not contribute to the corrosion of the metals, being instead the gaseous product of corrosion reaction.

38 **Inspections and Testing.** When boiler outages permit, thorough inspections should be made on all the internal parts of the boiler, to note the presence of corrosion in any form and for the collection of resultant deposits for later examination for corrosion products. Where any case of unusual and extensive corrosion is noted, the services of qualified personnel, such as the technical staff of the boiler manufacturer, the insurance company, or of a reputable consultant specializing in water treatment may be secured to determine causes and suggest remedial changes in water treatment and operation. This suggestion may be applied as well to the inspection of equipment ahead of and beyond the boiler. The laboratory inspection of deposits may furnish valuable information on corrosion. When boiler tubes require replacement for any reason, the rejected tube offers an excellent opportunity for a minute examination for the results of corrosion. Recording of the results of the inspections for future reference should be an established part of the inspection procedure.

39 Where the regular testing program of the station includes tests for the control of water treatment, either in the water treatment processes or for secondary treatment in the boilers, tests for noting corrosion reactions may be included, when considered desirable. These may include tests for dissolved oxygen and *pH* value, hydrogen, also carbon dioxide when high concentrations are encountered in normal operation. In general, these tests should be made on the feedwater entering the boiler, on the steam at one or more points in the cycle, and at such other points as a review of station design or the recommendations of the equipment manufacturer, insurance companies, or a reputable consultant specializing in water treatment may suggest. Tests should be made at sufficiently frequent intervals to detect variations in conditions which might influence the corrosion reactions.

40 **Correction of Conditions to Prevent Corrosion.** Damage sometimes attributed to corrosion may actually be influenced by erosion. Expert knowledge may be required to distinguish the causes.

41 Corrosion may be caused by dissolved gases in the feedwater. It is desirable to exclude such gases, especially oxygen, from the boiler feedwater by providing adequate mechanical equipment in the feedwater system for deaeration, and final clean-up, if necessary, in the boiler with available chemical scavengers.

42 The practical elimination of carbon dioxide and ammonia is a problem best referred to those specially qualified by training and experience to consider the factors in each individual case. The desirable minimum content of these substances is dependent on the quality of water available for boiler feed purposes, type of chemical treatment, and the design and operation of the station. The concentration of carbon dioxide in the steam condensate should be maintained at the lowest practicable level. The removal of ammonia requires special equipment.

CRACKING AND EMBRITTLEMENT OF BOILER STEEL

43 The development of cracks in the steel of boiler drums or tubes is evidence of a dangerous condition, the cause and correction of which should be determined immediately by thorough investigation by competent authority.

44 Cracking may develop from a variety of causes, is usually a result of stress or a combination of stress and corrosion, and is characterized as being transcrystalline (through the grain) or intercrystalline (along the grain boundaries).

45 Transcrystalline cracking (characteristic of corrosion fatigue) is due primarily to stress and is usually attributed to one or more of the following causes:

(*a*) The use of steel of unsuitable quality or the development of excessive internal stresses by imperfect heat-treatment or by cold working in the fabrication of the boiler;

(*b*) Abusive treatment such as over-rolling of tubes and failure to stress-relieve welded joints in the erection or repair of the boiler;

(*c*) Internal stresses set up by repetition of temperature changes, quenching action, or corrosion during the operation of the boiler;

(*d*) Stresses produced by expansion and contraction during heating and cooling of the boiler.

46 Transcrystalline cracking is found in tube failures due to laminated or defective metal, in drum nozzles or joints subjected to fluctuating temperatures and stresses, in over-rolled tube seats, in metal failures caused by vibration, in welded joints not properly stress-relieved, and in the checked and cracked surface of metal subjected to alternate overheating and quenching.

47 Intercrystalline cracking, more commonly known as caustic embrittlement, usually occurs below the water level and in joints, seams or cracks into which boiler water may leak and become highly concentrated. It is generally accepted that four simultaneous conditions are necessary to develop failure:

(*a*) The boiler water must contain substances, particularly hydroxides, capable of producing intergranular damage when concentrated in contact with stressed steel;

(*b*) There must be a joint or seam into or through which leakage of this boiler water may occur;

(*c*) The boiler water must concentrate within the joint or seam;

(*d*) The steel must be over-stressed locally where it is exposed to chemical concentration.

48 Such conditions may develop in seams in riveted drums and in rolled tube seats and result in embrittlement of the steel and ultimate failure by cracking. Operators should be suspicious of any leaks in the butt straps of riveted drums and in the tube seats of all boilers that cannot be readily stopped by caulking and re-rolling. No reports have been received of intercrystalline cracking in welded or forged drums.

49 Research and experience have indicated that the maintenance in the boiler water of certain ratios of usual boiler water salts, or of certain substances called inhibitors, may control this type of crack failure. The following methods have been suggested and used for control of embrittlement under a variety of operating conditions:

(*a*) Maintenance of certain concentrations of inhibitors in the boiler water;

(*b*) Use of feed water treatment yielding substantially no free hydroxide in the boiler water.

These methods should be established and supervised by personnel specially qualified by training and experience.

50 No fixed chemical control can be prescribed suitable for the whole range of boiler operating conditions. The embrittling tendency of a boiler water, with and without inhibitor treatment, may be determined with a mechanical device* which provides the necessary simultaneous conditions of leakage, concentration, and stress.

* One such device and its use are described in A.S.T.M. Method D807, Method of Field Test for Tendency of Boiler Water to Cause Embrittlement Cracking of Steels.

CARRYOVER, PRIMING, AND FOAMING

51 Carryover. The liquid and solid impurities carried out of a boiler with the generated steam are classified as carryover. The liquid impurity is the unevaporated boiler water and the solid impurity comprises the suspended and dissolved solids.

52 Carryover cannot be eliminated completely because the steam bears some spray, usually limited satisfactorily by drum baffles. Gross carryover usually results from priming or foaming. The amount of carryover permissible in the steam depends on the use to which the steam is put and on the equipment through which it may be passed.

53 Priming. Priming is the sudden carryover of water in large volumes into the steam space; it may be caused by a sudden change in demand or by surging or spouting in the drum. Priming causes slugs of water to pass out with the steam and results in sudden drop in superheat, shocks, and water hammer in the steam lines, and possible stripping of turbine buckets.

54 Foaming. Foaming is the term applied to the action in a boiler when steam bubbles, instead of breaking and releasing the steam, build up over the surface to form a layer of foam which fills the steam space and carries over into the steam system. Foaming may develop slowly or suddenly without visible change in water level and its effect on steam lines and turbines is similar to but less violent than the effect of priming. Foaming, however, often carries suspended matter and scum in addition to its dissolved solids and causes undesirable deposits in superheaters and on turbine blades as well as interfering seriously with lubrication in reciprocating engines. This form of carryover, due largely to the amount and type of impurities present in the water, is difficult to control by mechanical methods. The impurities which concentrate and cause foaming are dissolved solids and suspended matter, either of which may be of organic or inorganic origin.

55 Other factors beside boiler-water concentration, which affect carryover by foaming, are the water level, rate of steaming, changes in rating, rates of change in rating and pressure, steam pressure, amount and method of chemical feed to the boiler, boiler design, and method of firing.

56 Carryover Control. Priming and foaming represent an undesirable and often dangerous condition which should be investigated and corrected immediately. If the cause and correction are not evident, the assistance of personnel specially qualified by training and experience should be obtained.

57 Proper design of drum baffles and careful regulation of the water level are the usual methods of controlling priming.

58 While foaming is primarily the result of the concentration of the impurities in the boiler water, the degree or rate of foaming is sensitive to many operating conditions.

Foaming should stop or decrease under the following conditions:

(*a*) Reduction in boiler-water concentration by controlled blowdown. The maximum tolerable concentration will depend on the operating conditions of the individual plant;

(*b*) Elimination of saponifiable matter from boiler water;

(*c*) Reduction in rating or in rate of change in rating;

(*d*) Lowering of water level in drum;

(*e*) Decrease in rate of chemical feed to boiler;

(*f*) Improvement in steam-purification systems and drum baffles;

(*g*) Improvement in feedwater treatment system.

59 Analyses of the boiler waters accompanied by tests to determine the effect of the above factors will usually identify the cause and indicate the correction of the trouble. The amount of carryover under various operating conditions may be determined conveniently by calorimeter or electrical conductivity tests on the steam and by noting change in the superheated steam temperature.

60 Satisfactory control of boiler waters to prevent foaming generally requires a well-regulated and controlled plan for systematic blowdown with frequent chemical check tests of both the feedwater treatment and boiler-water conditions. Limits of operating conditions and the critical concentration should be established, and the operator instructed to keep within these limits.

SAMPLING, TESTING AND REPORTING OF ANALYSIS OF WATER AND STEAM SAMPLES

61 Since raw water for steam-generating purposes varies greatly from one locality to another, analyses preliminary to treatment design cannot be wholly standardized. Similarly, processes for economical treatment will vary from one locality to another and from one plant to another in a given locality. For these reasons, tests necessary for the control of treatment either external to the boiler, or so-called internal treatment, will vary and one set of such tests universally applicable for all plants is not justified.

62 Sampling of boiler feedwater, boiler water, steam or steam condensate, as well as raw water used in surface condensers, should be carried out in accordance with A.S.T.M. Standards.

63 Engineers are referred to A.S.T.M. Standards for recognized test procedures.

64 Field check tests generally will vary with the treatment used and the ratio of raw water to condensate comprising the feedwater. For this reason, specific tests to fit the particular needs of the situation under consideration should be recommended by personnel specially qualified by training and experience.

65 The results of water analyses should be reported as recommended in A.S.T.M. Standard Method of Reporting Results of Analysis of Industrial Waters (D-596). This may be supplemented by recalculation of the values to any desired basis.

NOTE: In view of the above addition as Part B, the following revisions and deletions of paragraphs relating to chemical aspects of boiler water of the present Suggested Rules will be recommended;

Par. No.	Proposed Revision
C-1.	In last sentence change reference to "Par. C-42" to "Part B"
C-25.	In last sentence change reference to "Pars. C-203 to C-209" to "Part B"
C-26.	In last sentence change reference to "Par. C-42" to "Part B"
C-27.	Add reference to "Part B"
C-42.	Delete specific directions, refer to "Part B"
C-44.	Change reference to "Pars. C-244 to C-248" to "Part B"
C-76.	Change reference to "Pars. C-202 to C-209" to "Part B"
Feedwater Supply (p. 30)	Reference to Pars. C-185 to C-209. Will require modification
C-203.	Add reference to "Part B"
C-204 to C-207	Delete
C-210.	In last paragraph add reference to "Part B"
C-211 to C-214	Delete
C-215.	Add reference to "Part B"
C-216 to C-220.	Revise or delete
C-221.	Add reference to "Part B"
C-222 to C-225.	Delete
C-226.	Add reference to "Part B"
C-227 to C-234.	Revise or delete
C-235.	Delete last sentence
Internal Corrosion.	Add reference to "Part B"
C-237 to C-248.	Delete
CA-1 to CA-27.	Delete

Errata

TABLE P-2. In the first printing of the 1946 edition of the ASME Power Boiler Code there is a typographical error at the top of page 9. The formula reading:

$$P = \frac{2.3\,S\,(t - 0.04)}{D} - \frac{S}{30}$$

should be deleted and the formula reading

$$P = \frac{2.875\,S\,(t - 0.04)}{D} - 0.045\,S$$

should be transferred below the line reading: "These formulas are derived from the general formula:"

Have You Seen the ASME Technical Digest?

DIGESTS of papers presented and to be presented at ASME meetings are published in this informative section. Papers published in MECHANICAL ENGINEERING are not included. This month's ASME TECHNICAL DIGEST section appears on pages 549 to 554. Turn now to these pages and keep abreast of all fields of mechanical engineering.

REVIEWS OF BOOKS

And Notes on Books Received in the Engineering Societies Library

Data Book for Civil Engineers

DATA BOOK FOR CIVIL ENGINEERS. By Elwyn E. Seelye. John Wiley & Sons, Inc., New York, N. Y. Vol. I, Design, 1945, cloth, $9\frac{1}{4} \times 11\frac{3}{8}$ in., 417 pp., illus., $7.50; Vol. II, Specifications and Costs, 1946, cloth, $9\frac{1}{4} \times 11\frac{3}{8}$ in., 325 pp., illus., $6.75; Vol. III, Field Practice, 1947, cloth, $4\frac{7}{8} \times 8$ in., 306 pp., illus., $4.50.

REVIEWED BY GEORGE R. RICH[1]

THE objectives in preparing these three very useful data books are concisely stated in the prefatory note to Volume 1.

(1) "To make readily available in one place effective data in each main field of civil engineering."

(2) "To make the work complete in itself so that a civil engineer isolated from other reference books and technical data could function."

(3) "To furnish data which will eliminate tedious office computing and thus minimize errors made in such computations."

(4) "To aid the engineer in attaining results in accordance with the best engineering practice by making available data based on such practice."

(5) "To expand the field of activity of the specialized engineer by providing him with handy data in fields allied to his specialty."

In concluding the preface, the author very properly cautions that "the data cannot be considered a substitute for intelligent judgment based on practice and consideration of all factors and phases of the specific problem at hand. For this reason, collateral reading is encouraged by abundant references."

Volume 1 on design contains what is probably the most comprehensive single collection of pertinent working data in civil-engineering literature, including sections on unit stresses, weights of materials, properties of structural-steel sections, concrete design tables and curves, timber design, soils, foundations, roads, railroads, airports, bridges, dams, waterfront structures, sewerage, and water supply.

A very complete tabulation of fully designed reinforced-concrete footings for various column loads and allowable soil pressures affords a good sample of the great wealth of time-saving information provided. Such tabulations are of the greatest usefulness in preparing cost estimates, as well as in final design. Many of the working elements of modern engineering science have been condensed into chart form. In the section on Soil Mechanics, charts are included to show the Boussinesq values of shearing and vertical stress under earth embankments. Evidently much care has been taken to employ the latest design practice. After a rather careful detailed scrutiny, the only obsolete formula detected was in connection with buckling of the compression flange in steel beams. In this case the outmoded $\frac{1}{b}$ criterion should be replaced by the modern AISC adoption of $\frac{1d}{bt}$ which gives fairer evaluation to broad flange beams.

Volume 2 appears to be predicated on the general principle that the preparation of specifications is in essence a work of compilation. The typical specifications, contracts, and invitation forms provide the requisite starting point and groundwork which can subsequently be expanded to suit the needs of the individual job and engineer. A very good range of cost-estimating data has been incorporated in this second volume. Inclusion of the date of each particular estimate and the corresponding *Engineering News Record* construction-cost index number will be particularly appreciated by appraisal engineers. A glossary of engineering terms constitutes an additional useful feature of Volume 2.

Volume 3 is an excellent condensed summary of essential topics for the field engineer written in the spirit of modern technological advances. Some of the topics included are concrete mixtures and inspection, structural steel including welding, timber, soils, paving, railroad curves and the care and adjustment of surveying instruments.

The author has been eminently successful in attaining his intended objectives. He makes no pretension of writing textbooks, but has concentrated his efforts upon providing a pertinent and complete collection of working tools. It is believed that the experienced designer or field engineer will require few additional sources of working data.

[1] Chas. T. Main, Inc., Boston, Mass. Mem. ASME.

Industrial Applications of Infrared

INDUSTRIAL APPLICATIONS OF INFRARED. By James D. Hall. McGraw-Hill Book Company, Inc., New York, N. Y., 1947. Cloth, 6 × 9 in., 201 pages, 139 illus., $3.50.

REVIEWED BY J. F. YOUNG[2]

DURING the last 10 years, infrared radiation has been applied to a great variety and number of industrial heating applications. Yet use of this tool is in its infancy and relatively little information has been available regarding it. Mr. Hall's timely book "Industrial Applications of Infrared" helps fill this need. It is a reliable reference which will answer questions regarding infrared and thereby promote its application.

In his book, Mr. Hall describes the available equipment for producing infrared radiation, explains its operating characteristics, and presents a fine compilation of design and installation data. Applications to such industries as metal finishing, wood finishing, textile, paper, plastics, and ceramics are well illustrated and described. Also included are discussions of several interesting domestic and nonheating uses and a bibliography of 61 items.

The emphasis, as the author states, is on the aspects of applying the method in practice, rather than on theoretical considerations. Basic formulas and calculations are omitted and the test approach is recommended for determining heating data for new applications. For those who are new in the field, a testing procedure is outlined. Also discussed are many factors which may affect selection of this heating method.

One criticism that may be leveled at the book concerns the technical content of the heat-transfer discussion. The clarity and completeness of this chapter could be materially improved. The coverage is,

[2] General Electric Company, Bridgeport, Conn. Jun. Mem. ASME.

however, sufficient for understanding the applications and characteristic data described and is within the author's objective of providing a nontechnical reference.

A second criticism is the very little space given to gas- or flame-type radiators and to lower-temperature radiators. Bulb-type electrical sources are referred to almost exclusively, and the data given apply to them.

Despite these two criticisms, the book is a valuable addition to the literature. It is well prepared and clearly presented. As a reference, it should prove most useful to the manufacturer or processor of finished goods. The great variety of applications illustrated and described should be of assistance to him, not only in the solution of specific problems, but also in suggesting additional uses for infrared heating.

Books Received in Library

ALUMINUM AND ITS APPLICATIONS. By H. Brown with the collaboration of A. Klemin and others. Pitman Publishing Corporation, New York, N. Y., and London, England, 1948. Cloth, $5^3/_4 \times 9^1/_4$ in., 338 pp., illus., diagrams, charts, tables, $5.75. A compilation of material written by various authorities in the field, this book presents the production processes and practical applications of aluminum and its alloys. The first eight chapters deal with fundamental properties and general usage. Definitions of metallurgical terms used are given. The later chapters discuss the present and future uses. Numerous illustrations and simple sketches demonstrate both fabrication methods and applications.

ANNUAL REPORT ON THE PROGRESS OF RUBBER TECHNOLOGY, Vol. 45, 1946, edited by T. J. Drakeley; published by W. Heffer & Sons, Ltd., Cambridge, England, for the Institution of the Rubber Industry, 12 Whitehall, London, S.W.1, England. Paper, $7 \times 9^1/_2$ in., 129 pp., tables; 12s, 6d to nonmembers; 4s, 6d to members of the Institution. Following a historical and statistical review are papers on natural and synthetic rubber. Testing equipment and processing are next discussed, followed by papers on the applications of rubber. An extensive reference list accompanies each paper. Officers and members of the Council of the Institution of the Rubber Industry are listed. There is a complete name index to both papers and references.

APPLIED JOB EVALUATION, a Manual of Installation and Operating Methods. By H. G. Stanway. Ronald Press Co., New York, N. Y., 1947. Cloth, $6 \times 9^1/_2$ in., 81 pp., charts, tables, $3.50. Intended as a manual of installation and operating methods, this book provides a definite and simple program for analyzing, describing, classifying and rating jobs. Detailed methods are given which may be applied to either large or small firms. A short list of books for reference reading is included.

ARGONARC WELDING (Collected Papers on Argonarc Welding presented to the LM.3 Committee on Fusion Welding of Magnesium-Rich Alloys) British Welding Research Association, London, England, May, 1947. Paper, $8^1/_2 \times 11$ in., 44 pp., illus., diagrams, charts, tables, 7s, 6d. The four papers collected in this publication give the results of certain investigations on the welding of magnesium alloys using the inert gas, argon, for shielding the arc. Diagrams and tabular data are effectively used to illustrate and supplement the text.

BEST'S SAFETY DIRECTORY of Safety, Hygiene, First Aid, and Fire-Protective Products. Second annual edition, 1948. *Safety Engineering Magazine*, a division of Alfred M. Best Company, Inc., New York, N. Y. Fabrikoid, 8×11 in., 494 pp., illus., diagrams, $5. Of interest to all concerned with the prevention of accidents, and the purchase and use of safety equipment, this guide contains information on many safety, first-aid, sanitation, and fire-protective products and devices. It shows what devices to use for specific hazards, how to use them, and where to get them. Local addresses of manufacturers are listed. The best practices and procedures for preventing specific accidents are given. The detailed product classification and equally detailed index increase the usefulness of the book.

COMING AGE OF ROCKET POWER. By G. E. Pendray, revised and enlarged edition, Harper & Brothers, New York, N. Y., and London, England, 1947. Cloth, $5^1/_2 \times 8^1/_2$ in., 255 pp., illus., diagrams, tables, $3.50. Written for the layman, this book traces the evolution of the rocket principle, gives a general description of rockets, and shows how they were developed and employed. Rocket societies and methods of research are also treated. This revised and enlarged edition contains a new chapter on the use of rocket power in pilotless aircraft and guided missiles in addition to the generalized forecast of the possibilities of rocket power.

ELEMENTARY MECHANICAL VIBRATIONS. By A. H. Church. Pitman Publishing Corporation, New York, N. Y., and London, England, 1948. Cloth, $6 \times 9^1/_4$ in., 200 pp., diagrams, charts, tables, $3.25. Based upon courses given at New York University, this book covers the elementary principles and serves as an introduction to more extensive study of vibration problems. The author stresses the physical rather than the mathematical explanations of the phenomena. One chapter is devoted to balancing. A knowledge of mechanics and calculus is assumed. Extensive use of examples clarifies the text, and problems, with answers, are given at the end of each chapter.

ELEMENTS OF NOMOGRAPHY. By R. D. Douglass and D. P. Adams. McGraw-Hill Book Co., Inc., New York, N. Y., and London, England, 1947. Cloth, $6 \times 9^1/_4$ in., 209 pp., diagrams, charts, tables, $3.50. This book deals with the study, understanding, creation, and practical use of the alignment chart. Seven elementary types are presented, including the circular nomograph. Practical aids to hasten and simplify the completion of the theoretical solution and the drafting of the chart are developed. Among these are the systematic adjustment of the scale measurements to the base line of the diagram, the regular use of prepared forms, and the practice of checking solutions. Compound alignment diagrams are dealt with in the final section.

HEAT. By A. G. Worthing and D. Halliday. John Wiley & Sons, Inc., New York, N. Y.; Chapman & Hall, London, England, 1948. Cloth, $5^3/_4 \times 9^1/_4$ in., 522 pp., illus., diagrams, charts, tables, $6. Dealing largely with "classical heat," this book emphasizes experimental methods. Each chapter contains appropriate theory, experimental procedures, results, and problems. Temperature measurement, specific heat, change of phase, and the three standard modes of heat transfer are discussed, as well as elementary thermodynamics and heat engines. Quantum considerations are given some attention.

HEATING AND VENTILATING BUYERS' DIRECTORY, 1948 edition, edited by C. Strock. Industrial Press, New York, N. Y., and Chicago, Ill. Paper, $5^1/_2 \times 8$ in., 320 pp., illus., $1. This book covers the fields of air conditioning, piping, heating, refrigeration, ventilation, and air sanitation. It is primarily a classified product directory, listing the sources of equipment, supplies, and services. A trade-name section includes both current and obsolete terms with the name of the manufacturer. Street addresses are given in the alphabetical list of manufacturers.

HEATING & VENTILATING'S ENGINEERING DATABOOK. By C. Strock. Industrial Press, New York, N. Y., 1948. Fabrikoid, $8^1/_2 \times 11^1/_4$ in., paged in sections, diagrams, charts, maps, tables, $7. Purely practical in character, this reference work emphasizes the data needed in actual design with only sufficient text to explain the use of the data. Information is included on the heat pump, electrothermal storage, snow melting, heating with Diesel engines, solar water heating, and radiant heating. One section is devoted to the law of contracts and other legal subjects which concern heating men.

HIGH-SPEED DIESEL ENGINES. By P. M. Heldt. Fifth edition. P. M. Heldt, Nyack, N. Y., 1947. Cloth, $5 \times 8^1/_2$ in., 479 pp., illus., diagrams, charts, tables, $6. The theory, design, application, operation, and maintenance of high-speed Diesel engines are presented. In this revised edition new material is included on the two-stroke engine, recently developed fuels, and cold-starting. A chapter on gas turbines has been added. A number of illustrations of large-scale sectional drawings of complete engines are given.

HISTORICAL APPRAISAL OF MECHANICS. By H. F. Girvin. International Textbook Co., Scranton, Pa., 1948. Cloth, $6 \times 9^1/_4$ in., 275 pp., diagrams, tables, $3.25. Tracing the history of mechanics from the early Greeks to modern times, this book stresses the relationship of mechanics to engineering education. It is divided into three parts. Part 1 discusses the early development of science and scientific thinking. The contributions from the Renaissance through Newton are considered in part 2, while part 3 is devoted to the mechanics of materials. A bibliography and chronological tables complete the text.

HOW TO PREPARE AND MAINTAIN A SUPERVISORS' POLICY MANUAL. (Research Report Number 21.) American Management Association, New York, N. Y., 1947. Paper, $6 \times 8^3/_4$ in., 71 pp., illus., tables, $3. Based on a survey of company practices, this volume deals, for the most part, with the actual techniques of collecting and appraising source material, writing the policies and procedures, coding and indexing them, and revising the manual as new material and changes develop. Both advantages and disadvantages of various procedures are reported.

HYDRAULICS. By H. W. King, C. O. Wisler, and J. G. Woodburn. Fifth edition. John Wiley & Sons, Inc., New York, N. Y.; Chapman & Hall, London, England, 1948. Cloth, $5^1/_2 \times 8^3/_4$ in., 351 pp., diagrams, charts, tables, $4. Considerably rewritten and brought up to date, this volume is concerned with the fundamentals of hydraulics and fluid mechanics. The sections on hydrostatics, hydrodynamics, pipes, and open channels have been expanded. They now include material on the hydrostatic relations for compressible fluids, the terminal velocity and the resistance of an object moving through a fluid, recent methods of computing friction losses in pipes, and discussion on the problems of reservoir discharge pipes. The problems have been redrafted.

IDRAULICA. By U. Puppini. Nicola Zanichelli, Editore, Bologna, Italy, 1947. Paper, 7×10 in., 678 pp., diagrams, charts, tables, 2500 lire. This comprehensive textbook presents the subject of hydraulics in a logical manner, proceeding from the units of measurement and other fundamentals through the general considerations to the more specialized aspects such as the use of models. Bibliographies accompany most of the chapters.

INDUSTRIAL ENVIRONMENT AND ITS CONTROL. By J. M. Dalla Valle. Pitman Publishing Corporation, New York, N. Y., and London, England, 1948. Cloth, $6 \times 9^1/_4$ in., 225 pp., diagrams, charts, tables, $4.50. This book deals with engineering methods for the control of health hazards in factories. It presents extensive details on air sanitation and exhaust ventilation. Illumination, noise, and thermal environment are fully discussed. The scope of industrial hygiene is indicated and general principles of industrial sanitation are included. References follow each chapter. No prerequisites other than preliminary engineering and some knowledge of industrial hygiene are required.

LOCOMOTIVE CYCLOPEDIA of American Practice 1947. Thirteenth edition, edited by R. V. Wright and R. C. Augur. Simmons-Boardman Publishing Corporation, New York, N. Y., 1947. Cloth, $8 \times 11^3/_4$ in., 1418 pp., illus., diagrams, charts, tables, $8. This standard reference book presents the latest practices in American locomotive building. It contains a dictionary of terms and data on steam, electric, and Diesel-electric locomotives for industrial and export purposes. Different parts and accessories are described in detail, locomotive maintenance and operation are thoroughly covered, and an index to trade names is provided. New features are a bibliography of the literature on locomotive-shop and engine-terminal layout, operation and practices, and material on recent applications of Diesel engines. Over 4000 photographs and dimensional sketches illustrate the text.

MANUAL OF MATHEMATICS AND MECHANICS. By G. R. Clements and L. T. Wilson. Second edition, McGraw-Hill Book Company, Inc., New York, N. Y., and London, England, 1947. Cloth, $6 \times 9^1/_4$ in., 349 pp., diagrams, tables, $3.25. This manual contains facts and formulas that are useful in colleges and engineering schools. In this revised edition the tables of differentials and integrals have been expanded, and the author has included formulas for the solution of spherical triangles by Ageton's method. New material has also been added on the applications of mathematics to certain topics in electrical engineering. A glossary and tables for use in courses in physics are appended.

METAL PROCESS ENGINEERING. By N. E. Woldman. Reinhold Publishing Corporation, New York, N. Y., 1948. Cloth, $6 \times 9^1/_4$ in., 291 pp., illus., diagrams, charts, tables, $5. Based on a postgraduate course, this book contains material on various practical phases of metallurgical engineering and metallurgical processes. It discusses casting, forging, joining of metals, and heat-treatment as well as surface hardening and the machining of metals. Tool steels and the mechanical working of metals and alloys are treated. References to more detailed information follow each chapter. Many illustrations and diagrams complement the text.

NOMOGRAPHY. By A. S. Levens. John Wiley & Sons, Inc., New York, N. Y.; Chapman & Hall, Ltd. London, England, 1948. Cloth, $5^3/_4 \times 9^1/_4$ in., 176 pp., diagrams, charts, tables $3. Of interest to the scientist and practicing engineer this book presents fundamental principles of the design and theory of an important graphical method. Emphasis is placed on the geometric method of development and after the theory is explained, short cuts are described. A knowledge of algebra, plane geometry, and logarithms is assumed. One chapter is devoted to the use of determinants in alignment chart work. Practical examples of charts and a selected bibliography are included.

NOTE INTRODUCTORY TO THE THEORY AND DESIGN OF GAS TURBINES. By J. Small. Published by the author at the James Watt Engineering Laboratories, University of Glasgow, Glasgow, Scotland, 1947. Paper, $5^1/_2 \times 8^1/_4$ in., 67 pp., diagrams, charts, tables, 7s, 6d. This book explains the principles of the gas turbine. It is intended for use by those in the engineering field who wish to understand the basis of this engine. Diagrams and calculations amplify the text. Descriptive and historical matter are omitted.

PLANNING FACTORY MAINTENANCE. ("Mechanical World" Monographs, No. 41.) By F. D. Denner. Emmott & Co., Ltd., London, England, 1947. Paper, $4 \times 6^1/_2$ in., 29 pp., tables, 1s, 6d. This small pamphlet presents practical schedules and incentives for the effective maintenance of factory equipment and the efficient continuance of production.

PLASTICS DICTIONARY. By T. A. Dickinson. Pitman Publishing Corporation, New York, N. Y., and London, England, 1948. Cloth, $6 \times 9^1/_4$ in., 312 pp., diagrams, tables, $5. This book contains some 3500 commonly used terms. Trade names, base words, and combining forms are included, as well as some British terminology. Drawings are used in some instances to explain fully the exact meaning. Various tables and charts give practical data and a bibliography lists both books and magazine titles.

POWDER METALLURGY, Its Physics and Production. By P. Schwarzkopf. The Macmillan Company, New York, N. Y., 1947. Cloth, $6 \times 9^1/_2$ in., 379 pp., illus., diagrams, charts, tables, $8. Covering the entire field of powder metallurgy, this volume contains information on the industrial processing of metal powders and the products obtainable. The theories on which powder metallurgy is based are also discussed, as well as the latest developments and future possibilities. The available literature is reviewed and bibliographies on processing, products, principles, and possibilities for the future are included. It is not intended as a text but rather represents the workbook of an experienced powder metallurgist.

POWER SYSTEM STABILITY. Volume 1, Elements of Stability Calculations. By E. W. Kimbark. John Wiley & Sons, Inc., New York, N. Y.; Chapman & Hall, London, England, 1948. Cloth, $5^1/_4 \times 8^1/_2$ in., 355 pp., illus., diagrams, charts, tables, $6. This first volume of a projected three-volume work covers the elements of the stability problem, the principal factors affecting stability, the simplified methods of making stability calculations, and the practical application of these methods to actual power systems. Information is given on a-c calculating boards (network analyzers), and curves are included which largely eliminate the need for computation of swing curves of two-machine systems. Transient stability is stressed throughout.

PRACTICAL EVALUATION OF RAILROAD MOTIVE POWER. By P. W. Kiefer, published and distributed by Steam Locomotive Research Institute, Inc., New York, N. Y., June, 1947. Cloth, $5^1/_4 \times 8^3/_4$ in., 65 pp., illus., diagrams, charts, tables, $2. Backed by experience with steam and Diesel-electric locomotives used in the same service, the author effectively compares, from several fundamental aspects, the service value of these important types. Availability for service, cost, work capacity, and performance efficiency are considered on a basis of factual data, and the derived conclusions are given. A brief note on the gas-turbine locomotive is included.

PRINCIPLES OF INDUSTRIAL MANAGEMENT. By N. A. Allcut. Fourth edition. Sir Isaac Pitman & Sons, Toronto, Canada, 1947. Cloth, $6 \times 9^1/_4$ in., 308 pp., illus., diagrams, charts, tables, $4. Intended for use by students as a text, this volume does not attempt to describe the details of industrial administration. After a discusson of the general principles of management, the specific topics of organization, reports, purchasing, budgets, planning, work routing, and stockroom procedures are treated. A chapter on time and motion study is included as well as chapters on inspection, costs and cost keeping, industrial labor relations, and waste.

PRINCIPLES OF JET PROPULSION AND GAS TURBINES. By M. J. Zucrow. John Wiley & Sons, Inc., New York, N. Y.; Chapman & Hall, London, England, 1948. Cloth, $5^3/_4 \times 9^1/_4$ in., 563 pp., diagrams, charts, tables, $6.50. Presenting the basic principles and analytical methods employed, this volume contains the facts necessary for an understanding of jet propulsion. The author treats the workings of the continuous combustion gas turbine, the turbojet engine, the three basic types of air compressors, the axial-flow turbine, and the rocket. The combustion chamber and high-temperature metallurgy are also considered. Extensive use of examples, equations, tables, and illustrations amplify the text; 274 references furnish a guide to further reading.

PRINCIPLES OF QUANTUM MECHANICS. By P. A. M. Dirac. Third edition, Clarendon Press, Oxford, England; Oxford University Press, New York, N. Y., 1947. Cloth, $6 \times 9^1/_2$ in., 311 pp., tables, $9. Rewritten to include the results of research since 1935, the main alteration is the introduction of the notation of bra and ket vectors. The presentation of the theory of systems with similar particles is now based on Fock's treatment of the theory of radiation. A further development of quantum electrodynamics, including the theory of the Wentzel field, has been included.

REVIEW OF METAL LITERATURE, volume 3, 1946, prepared for the members of the American Society for Metals by Battelle Memorial

Institute, Columbus, Ohio. American Society for Metals, Cleveland, Ohio, 1947. Cloth, 6 × 9¼ in., 811 pp., $15. An annotated survey of articles and technical papers appearing in engineering, scientific and industrial journals, and books, here and abroad. The subjects covered range from ores and raw materials through industrial uses and applications of the finished product. Technical books in this field are also reviewed. The addresses of the 300 publications covered are given. Cross references aid in the location of abstracts, and both an author and a detailed subject index are provided.

PROBLEMS OF ACCELERATING AIRCRAFT PRODUCTION DURING WORLD WAR II, a Report by T. Lilley and others. Harvard University, Graduate School of Business Administration, Division of Research, Boston, Mass., 1947. Paper, 8½ × 11 in., 112 pp., charts, tables, $1.50. This report analyzes the types of time-consuming problems which had to be solved before wartime production goals could be reached. Problems discussed include airframe and engine production, company management, facilities, materials, and manpower. The intention is to provide not only a historical survey, but also a helpful guide to the solution of normal administrative problems.

RUNNING A MACHINE SHOP. By F. H. Colvin and F. A. Stanley. McGraw-Hill Book Co., Inc., New York, N. Y., Toronto, Canada, London, England, 1948. Cloth, 5 × 8½ in., 521 pp., illus., diagrams, charts, tables, $4.25. Modern shop practice, planning, and equipment are first dealt with, followed by materials handling, toolrooms, and tool cribs. Production routing and estimating are covered in detail. Management, inspection, training, and personnel relations are considered in the later chapters. The postwar supplement added to this edition deals largely with management problems such as job evaluation, etc.

SCIENCE OF PLASTICS, Volume 1. Edited by H. Mark and E. S. Proskauer and others. Interscience Publishers, Inc., New York, N. Y., and London, England, 1948. Cloth, 6½ × 10 in., 632 pp., illus., diagrams, charts, tables, $9. This volume contains abstracts of the literature on plastics for 1942–1946. An unusual feature of these abstracts is the inclusion of technical data tables and graphs from the original article. Originally published in loose-leaf form, the material has now been oragnized and indexed. The four sections of this volume deal with general aspects such as properties and evaluation, physical chemistry, reaction kinetics, and technology. Each paper deals with more than one plastic. Future volumes will group the papers on individual plastics.

SOCIETY FOR EXPERIMENTAL STRESS ANALYSIS, Proceedings, Vol. 5, no. 1, edited by C. Lipson and W. M. Murray. Society for Experimental Stress Analysis, Cambridge, Mass.; published and distributed by Addison-Wesley Press, Inc., Cambridge, Mass. Cloth, 8½ × 11¼ in., 136 pp., illus., diagrams, charts, tables, $6. The fifteen papers contained in this volume deal with various aspects of the following subjects: strain gages, impact testing, telemetering, x-ray analysis, fatigue, and other stresses. Also included are a list of members and contents pages for volumes 2, 3, and 4.

STEEL AND ITS HEAT TREATMENT, 2 volumes. Fifth edition. By D. K. Bullens and the Metallurgical Staff of the Battelle Memorial Institute. John Wiley & Sons, Inc., New York, N. Y.; Chapman & Hall, Ltd., London, England, 1948. Cloth, 5¾ × 9¼ in., illus., diagrams, charts, tables; volume 1, 489 pp., $6; volume 2, 293 pp., $4. The purpose of this book is to help the steel technician to understand and to control the processes he handles. Volume 1 explains the principles behind heat-treatment of both carbon and alloy steel and stresses the necessary definitions and terminology. The authors discuss the uses the limitation of tests to evaluate the suitability of steel for heat-treatment and to determine proper engineering uses for heat-treated products. Volume 2 gives the practical applications of the heat-treating principles covered in volume 1. Furnaces, quenching media, and other tools are discussed. The penalties incurred by disobedience of principles are indicated. Methods of preventing cracking and distorting, preparation of steel for machining, the relation of heat-treatment to welding, and the heat-treatment of steel castings, malleable iron, and cast iron are important topics covered.

SYMPOSIUM ON METALLURGY OF STEEL WELDING. Published by British Welding Research Association, London, England, 1947. Cloth, 8¼ × 11¼ in., 104 pp., illus., diagrams, charts, tables, 10s. This book is composed of the papers presented at the first postwar symposium of the British Welding Research Association. The first two sessions were devoted to weld metal, the third to hardened zone cracking and viscosity of welding slags, and the final session to current research. The papers given at this final session were on the electrophysics of the welding arc and the cracking of welded gas mains. Both the verbal and written discussions of the papers are included.

TABLES OF THE BESSEL FUNCTIONS OF THE FIRST KIND OF ORDERS TEN, ELEVEN, AND TWELVE. (Harvard University, Annals of the Computation Laboratoy, volume 7.) TABLES OF THE BESSEL FUNCTIONS OF THE FIRST KIND OF ORDERS THIRTEEN, FOURTEEN, AND FIFTEEN. (Harvard University, Annals of the computation Laboratory, volume 8.) TABLES OF THE BESSEL FUNCTIONS OF THE FIRST KIND OF ORDERS SIXTEEN THROUGH TWENTY-SEVEN. (Harvard University, Annals of the Computation Laboratory, volume 9.) Harvard University Press, Mass., 1947–1948. Vol. 7, no pagination; vol. 8, no pagination; vol. 9, 764 pp.; cloth, 8 × 10¾ in., tables, $10 each. In these three volumes are continued the tables computed by the Automatic Sequence Controlled Calculator. The tabulation is carried to ten decimal places, with a wide range of argument and order, fine argument interval, and a high degree of accuracy. The Tables are intended to be of use not only to mathematicians but also in the designing departments of electrical and radio industries and in many kinds of laboratories. Volume 3 of the series describes the methods of computation and interpolation.

TECHNOLOGICAL AND PHYSICAL INVESTIGATIONS ON NATURAL AND SYNTHETIC RUBBERS. (Monographs on the Progress of Research in Holland.) By A. J. Wildschut. Elsevier Publishing Co., New York, N. Y., and Amsterdam, Holland, 1946. Paper, 5¾ × 8¼ in., 173 pp., illus., diagrams, charts, tables, $3. This book contains a survey of the investigations in the field of rubber and rubberlike materials which were carried out in the Netherlands during the war. It is divided into two sections which deal respectively with technological and physical investigations. The standard measurements made of real rubbers and rubberlike thermoplastics are included. The vulcanization process and its effects are discussed. Results of structural research and x-ray and electrical investigations are given.

TEXTBOOK OF HEAT. By G. R. Noakes. Macmillan and Co., Ltd., London, England, 1947. Cloth, 5½ × 8 in., 469 pp., illus., diagrams, charts, tables, $3. Beginning with methods for measuring temperature and heat energy, this elementary text covers the expansion of solids, liquids, and gases; vapor pressure; heat and work; heat engines; low-temperature production; and heat transfer. The final chapter deals with heat phenomena in the atmosphere from the meteorological point of view.

THEORY OF LIMIT DESIGN. By J. A. Van den Broek. John Wiley & Sons, Inc., New York, N. Y., Chapman & Hall, London, England, 1948. Cloth, 5½ × 8½ in., 144 pp., illus., diagrams, charts, tables, $3.50. This book presents the fundamental principles on which the theory of limit design is based. By presupposing ductile rather than elastic distribution, design emphasis is shifted from permissible safe stresses to permissible safe deformations. Column action is treated at length. Problems, formulas, and examples clarify the discussion.

THERMODYNAMICS. By L. C. Lichty. Second edition, McGraw-Hill Book Co., Inc., New York, N. Y., and London, England, 1948. Cloth, 6 × 9¼ in., 341 pp., diagrams, charts, tables, $4.50. This standard text groups the subject matter according to method of analysis rather than according to media and mechanical equipment, in order to develop the student's analytical ability. In this revised edition the text has been extensively rewritten to simplify, improve, and extend the understanding of thermodynamics and its application to engineering processes. New material includes sections on nonsteady-flow processes and on gas turbines.

TIMBER ENGINEERS' HANDBOOK, edited by H. J. Hansen. John Wiley & Sons, Inc., New York, N. Y., Chapman & Hall, Ltd., London, England, 1948. Cloth, 5½ × 8½ in., 882 pp., diagrams, charts, tables, $10. Covering all the woods used in this country, this book contains the latest information necessary for the design of wood structures. Wood properties, grading specifications, working stresses, preservatives, fastenings, design formulas, and methods are presented. Thirty charts, 120 figures, and more than 100 tables illustrate the text and provide useful data. Standard terms are defined and common abbreviations explained. Safe uniformly distributed loads for beams of various sizes and lengths are tabulated in a 500-page appendix.

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ASME NEWS

And Notes on Other Engineering Societies

COMPILED AND EDITED BY A. F. BOCHENEK

Engineers Joint Council Urges Deferment of Engineers at Congressional Hearing

DEFERMENT of the nation's engineering man power in selective-service legislation now pending was urged on Congressional legislators by Lawrence W. Bass, chairman of the Engineers Joint Council's Committee on Selective Service Legislation, as a measure of conservation of a valuable but limited national asset and as an insurance that available engineering and scientific talent would be used at its maximum professional competence during the current shortage of engineers.

In a statement before a hearing of the House Committee on Armed Forces on April 16, 1948, Dr. Bass, who is vice-president in charge of research and development of U. S. Industrial Chemicals, Inc., New York, N. Y., recommended the following points for legislative consideration:

1 Creation of a special board under a suitable agency to review the cases of engineers, scientists, and technologists.

2 Provision for the training of an adequate number of students in engineering and science.

3 Provision for an adequate number of university teachers and research workers to implement the educational program.

Engineers Back Armed Forces

As spokesman for 98,000 engineers of professional status, who are members of the five constituent Societies of the EJC, Dr. Bass said, "engineers are solidly behind the Armed Services in all their needs for technical personnel used in professional capacities to the extent of their abilities."

Referring to the short supply of engineers, Dr. Bass continued:

There are not enough engineers. The depression had its effects in curtailing education, and on top of that came a war which saw the young logical material for scientific and engineering training, fingering guns instead of slide rules. These shortages, created by economic and martial disruption, will be felt for many years. The vacuum created in technology by a continued shortage of trained men—men who should even now have 4 to 14 years of experience—can never be filled.

The value of the engineers in our economy is a fact—it is not even arguable. To me it seems obvious, in view of their value, and in view of their shortage, that we should conserve those we have. In time of war it would be unthinkable to draft a doctor into any post which did not make full use of his training. Why? Though the answer is obvious it is made to point out similarities. Physicians are of direct use in maintaining the health of the troops and of the public. Since doctors, too, are in short supply, they must be utilized either in the Army, or in maintaining the health of the civilian population backing up the Army. No doctor is wasted! Now the analogy I wish to make is that engineers fill a similar function from a similar short-supply position. There are not enough engineers, and each ought to be used in his full capacity either as an engineer in the Armed Services, or in maintaining the industrial strength of the country which backs up our military strength. Because the work of the physician is so personal, and the work of the engineer so impersonal, this point doubtless does not occur to everyone. Yet the engineers were not fully utilized in the recent war—a waste equally as serious as though thousands of medical men had been drafted into the Services to scrub barracks as a sanitation measure.

I think that insurance against wasting technical training and experience can be obtained rather simply. You will recall that there was considerable confusion about the handling of engineers and scientists under the early selective-service regulations. There finally evolved, based on necessity and hard-won experience, a suitable procedure for conserving our limited supply of technical men. A special committee was set up under the War Production Board, composed of industrial technical men, which met on a regular schedule, and which considered every case on its merits. This procedure was implemented late in the war by Local Board Memorandum No. 115.

Criteria for Deferments

I recommend for your consideration the establishment of a similar special committee under suitable auspices—the National Security Resources Board, for example—to examine all deferment cases involving engineers, scientists, and technologists. Recommendations for deferment would necessarily rest in a given case upon the following criteria: (1) The training and experience of the individual; (2) his utilization at the highest level of his ability; and (3) the importance of his work in the national interest.

It is essential, further, that an adequate flow of young engineers and scientists be maintained. In my opinion it would be practical to establish, under a suitable agency, a program for selecting a quota of students whose records warranted an opportunity to continue their technical training.

To provide teaching and research faculties in our technical schools to implement such a program of engineering and scientific training, provision should be made for deferment of qualified men.

WES Moves to New Headquarters

THE Western Society of Engineers has recently completed its move to new headquarters which, when fully renovated and equipped, will serve as an engineering and scientific center in Chicago, Ill.

W. V. Kahler, WES president, has estimated that the society will spend $100,000 on meeting rooms, offices, lounges, and dining facilities on the fifth, sixth, and seventh floors of the building at 84 East Randolph Street near the John Crerar Library.

June News High Lights

SELECTIVE Service modifications which would permit deferment of engineers were urged by the Engineers Joint Council in a statement made by L. W. Bass before the House Committee on Armed Services (565).

The Aviation Division will hold its 1948 annual conference in Dayton, Ohio (569).

Representatives of American and European engineering societies held an informal conference in Copenhagen, Denmark, which explored steps to promote international co-operation among engineers (567).

The fact that the average age of machine tools in the United States is 18 years and that these tools are rapidly becoming obsolete was pointed out at the Machine-Tool Electrification Forum sponsored by the Westinghouse Electric Corporation (566).

Higher operating costs are responsible for an increase in charges for services provided by the Engineering Societies Library (569). The first of a series of bibliographies for engineers compiled by the ESL deals with filing systems for engineering offices (566).

For the nonphysicist who wants to know what is happening in the field of physics, the American Institute of Physics is publishing a new monthly magazine, *Physics Today* (569).

ESL Publishes Bibliography on Engineering Office Filing

TO AID the engineer who wants information on how to systemize engineering office files, the Engineering Societies Library, 29 West 39th St., New York, N. Y., has just published, "Filing Systems for Engineering Offices," a selected list of 41 references to books and articles on systems for the filing of notes, correspondence, abstracts, reprints, drawings, maps, and catalogs. Some of the articles listed describe general filing systems, while others refer specifically to the various fields of engineering and to such diverse industries as pulp and paper, plate-metal shops, gas, petroleum, and metallurgy. The articles describe systems that have been found satisfactory for personal and office use. An annotation summarizes the important features of each article.

The list is the first of a series of bibliographies to be issued by the Engineering Societies Library, and may be purchased from the Engineering Societies Library, 29 West 39th St., New York 18, N. Y. Price is $2.

ASME Calendar
of Coming Events

June 17–19, 1948
ASME Applied Mechanics Division Meeting, Illinois Institute of Technology, Chicago, Ill.

Sept. 7–9, 1948
ASME Fall Meeting, Reed College, Portland, Ore.

Sept. 13–17, 1948
ASME Instruments and Regulators Division Meeting, Convention Hall, Philadelphia, Pa.

Sept. 20–21, 1948
ASME Aviation Division Meeting, Hotel Dayton Biltmore, Dayton, Ohio.

Oct. 3–6, 1948
Petroleum Committee of the ASME Process Industries Division Meeting, Herring Hotel, Amarillo, Texas.

Nov. 3–4, 1948
ASME Fuels Division Meeting, Greenbrier Hotel, White Sulphur Springs, W. Va.

Nov. 28–Dec. 3, 1948
ASME Annual Meeting, Hotels Pennsylvania and New Yorker, New York, N. Y.

Jan. 10–14, 1949
Materials Handling Division and Management Division Meeting, Convention Hall, Philadelphia, Pa.

(For other meetings see page 569)

MEETING OF THE REGIONAL ADMINISTRATIVE COMMITTEE OF ASME REGION IV HELD AT SAVANNAH, GA., APRIL 4–6, 1948

(At such meetings in the spring, Regional officers of each of the eight ASME Regions meet to discuss Society affairs and to elect Regional representatives to the Regular Nominating Committee and to the Regional Delegates Conference held during the Semi-Annual Meeting.)

Westinghouse Sponsors Machine-Tool Electrification Forum

THE Twelfth Annual Machine-Tool Electrification Forum was held by the Westinghouse Electric Corporation at the Statler Hotel, Buffalo, N. Y., April 22–23, 1948. Representatives from more than 100 firms were present. About 140 Westinghouse representatives were also present to answer questions and cover points raised during the forum.

It was not possible to visit the Buffalo plant, but G. H. Welch, manager of the Industrial Control Division, explained the present distribution of equipment and the addition to the original plant made necessary by moving the Industrial Control Division from Pittsburgh, Pa., to Buffalo. The present plant now houses both the Industrial Control Division and the Motor Division. According to Mr. Welch, the new plant involves the expenditure of three million dollars, of which $1,830,000 was expended in the purchase of new equipment to take care of advanced methods and to replace equipment not moved from Pittsburgh. The total amount includes the expense in moving 275 families to cover the shift of key personnel.

The development of electronic control was demonstrated by a display of Mot-O-Trol. A fractional-horsepower motor was put through a number of operations to show the complete control and accuracy of control that can be obtained electronically. Standard equipment can now be used on a wide variety of motors ranging from fractional horsepower to 25 horsepower and special equipment is available for larger motors.

In his address of welcome, L. R. Ludwig, manager of the Buffalo Division, expressed regret at the change in plans that prevented a visit to the plant and pointed out that in spite of adverse conditions not over ten hours had been lost through labor trouble since opening the plant in Buffalo.

Carl Taylor, president of the Waukesha State Bank, addressed the luncheon meeting, taking as his subject "What Made America a Great Country." Actually the theme of Mr. Taylor's talk was woven around the question, "What kind of a world do you want to live in tomorrow and your children to live in the day after tomorrow?" A number of statistics were introduced in connection with this theme to draw a comparison between living conditions in this country as compared to those in other parts of the world and to emphasize the need for individual thinking for successful advancement.

In closing the meeting, Tell Berna, general manager of the National Machine Tool Builders Association, gave a report on the machine-tool industry as it exists today. He pointed out that one of the reasons for rapid progress in the development of industry in this country was the development of new equipment and the replacement of obsolete equipment. As a matter of comparison he reported that before the war, machines as much as 30 years old were still in use in Europe, whereas the average age of equipment in this country at the present time was 18 years. Because of recent developments in machine tools, with a corresponding increase in feeds and speeds, much of the equipment now in use in this 18-year span was now obsolete having been superseded by machines better able to carry the loads for which tools were now available and the power for which the machines could be equipped. It was strongly emphasized that the wealth of a country lay in the man hours wisely applied in industry.

R. B. S.

Informal International Conference Held at Dedication of Headquarters of Danish Civil Engineers

LESS than three years after it was destroyed by aerial bombardment, the headquarters building of the Danish Civil Engineers in Copenhagen, Denmark, was reconstructed and officially opened on Jan. 21, 1948, in the presence of Danish cabinet, parliament officials, and representatives of many foreign engineering institutions.

In spite of difficult postwar conditions so unfavorable to new construction, Danish engineers succeeded in rebuilding a headquarters which might well serve as a model for American engineering centers. The new structure has four floors and contains auditoriums of various capacities, conference rooms, lounges, and a restaurant and recreation room to answer all the professional and social needs of a technical organization.

Danish Engineers Honored

As part of the dedication ceremonies, tablets were unveiled in honor of Viggo Borsholt and 21 Danish civil engineers killed during the war. Mr. Borsholt, who was vice-president of the society, was shot by order of the Germans in the spring of 1944 as he was on his way to the office. The other engineers were either shot by the Germans in Denmark or died in concentration camps or in service abroad.

Many of the rooms of the new building contain gifts presented by foreign societies. The Society of Danish Civil Engineers in Great Britain presented a collection of oriental rugs. Nine paintings were presented by The Norwegian Engineering Society. Special lighting fixtures of Orrefors glass were denoted by The Swedish Engineering Society, while a decoration of Delft wall tile came from The Dutch Engineering Society.

International Co-Operation Discussed

On the second day of the ceremonies, an informal meeting of foreign representatives was held to discuss with Danish engineers some of the problems of mutual interest. Twenty engineers, including A. K. Bak, Municipal Electric Works, Copenhagen, Denmark, official ASME representative, participated. Among topics discussed were the advantages of regular informal meetings of the officers of the principal engineering institutions of the world for purposes of mutual aid on common problems. The question was raised whether interchange of membership privileges was practicable. Another point explored was the advantages of foreign employment for young engineers as part of their professional experience. The desirability of easing the foreign-exchange situation to facilitate foreign memberships and some steps toward uniform international qualification of membership in engineering societies was also taken up.

There was general agreement among the representatives of the efficacy of informal collaboration among engineering institutions as compared to a formal international organization in bringing about international co-operation in the profession. It is expected that the conversations initiated in Copenhagen will be continued in October, 1948, at the conference called jointly by the three principal institutions of Great Britain, The Institution of Civil Engineers, The Institution of Mechanical Engineers, and The Institution of Electrical Engineers.

AIEE-ASME Specifications for Prime-Mover Speed Governing Available

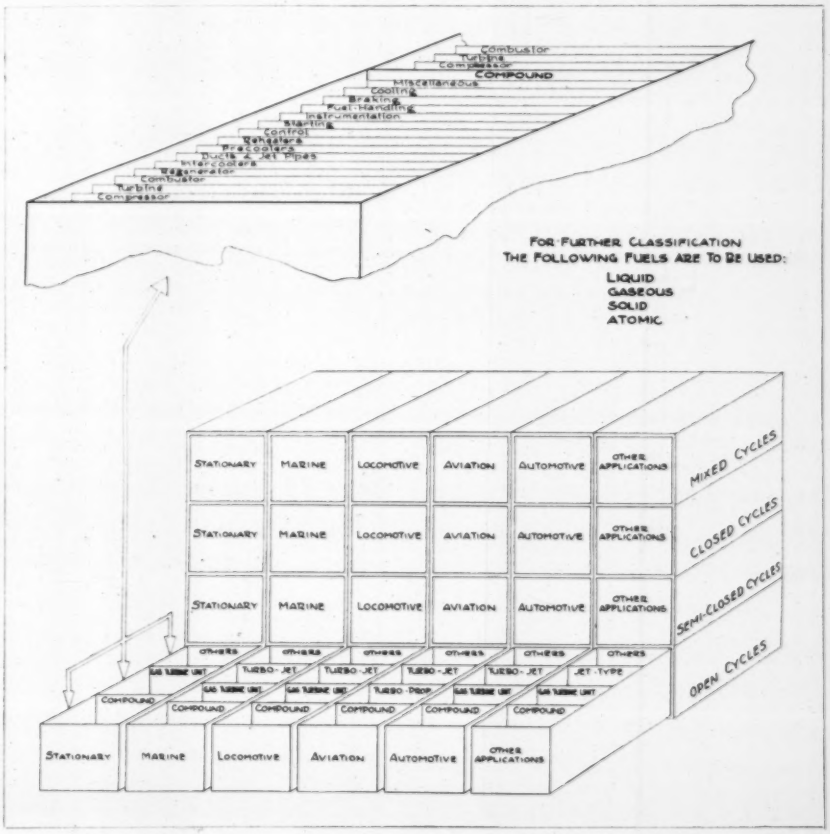
AS A result of joint effort by the American Institute of Electrical Engineers and The American Society of Mechanical Engineers, two papers are now available covering recommended specifications for speed governing of prime movers intended to drive electric generators.

The papers are the results of joint projects sponsored by the AIEE Power Generation Committee and the ASME Power Test Code Committee to end confusion about values of desirable, possible, and acceptable performance characteristics for speed governing of prime movers and in nomenclature employed in this field.

The first paper, "Recommended Specification for Speed-Governing of Steam Turbines Intended to Drive Electric Generators Rated 500 Kw and Up" (AIEE Miscellaneous Paper 48-4), presents specifications limited in scope to the following types of steam turbines: Straight condensing; straight noncondensing; and nonautomatic extraction turbines with and without initial or exhaust steam-pressure control; also automatic extraction and mixed-pressure turbines.

The second paper, "Recommended Specification for Speed-Governing of Hydraulic Turbines Intended to Drive Electric Generators" (AIEE Miscellaneous Paper 48-5), covers recommended minimum functional and performance characteristics relating to governors for the following types of hydraulic turbines: impulse; Francis; fixed-blade propeller; and adjustable-blade propeller.

Copies may be obtained from the American Institute of Electrical Engineers, 33 West 39th St., New York 18, N. Y. Price per copy to AIEE and ASME members is 35 cents, and to nonmembers, 65 cents.



THIS SKETCH ILLUSTRATES THE SCOPE OF THE ASME GAS TURBINE POWER DIVISION. IT WAS PREPARED BY R. TOM SAWYER, PAST-CHAIRMAN OF THE DIVISION'S EXECUTIVE COMMITTEE

Headquarters News Notes

THE Boiler Code Committee will hold a social session at Echo Lake Country Club, Westfield, N. J., June 24, 1948. The regular June meeting of the Committee will be held the next day.

A brochure on the preparation, submission and publication, and presentation of papers before the Society has been prepared by the Board on Technology for the benefit of ASME authors.

A new Membership List is to be published in the fall. Members are urged to fill out the form on page 571 so that the new list will contain accurate information.

The ASME is making a grant of $10,000 to Harvard University to cover the first year's research work on pressure-viscosity relations of lubricants, a project sponsored by the ASME Research Committee on Lubrication.

Funds are being sought from industry to support ASME research on measurement of small rates of flow. The project will provide design and performance data on small orifices, nozzles, and Venturies in small pipes and channels.

Another ASME research project, still in the planning stage, is one which will seek to determine viscosities and thermal conductivities of technically important gases at high temperatures and pressures. This project was suggested by a survey of the present state of knowledge of gas properties and on industrial needs for research in this field, made recently by the ASME Research Committee on Properties of Gases and Gas Mixtures.

CROWN POINT ON THE COLUMBIA RIVER GORGE, ONE OF THE PLACES TO BE VISITED BY MEMBERS ATTENDING THE ASME 1948 FALL MEETING AT REED COLLEGE, PORTLAND, ORE.

S. A. Tucker Made Standards Manager for ASME

STANDARDS Department of The American Society of Mechanical Engineers, which handles programs of ASME Boiler Construction Code, Power Test Codes, Safety Codes, and development of dimensional standards under procedure of American Standards Association, will be headed by S. A. Tucker, Mem. ASME, formerly managing editor of *Electrical World*, a McGraw-Hill publication.

Mr. Tucker brings to ASME more than ten years of editorial experience on the staffs of *Power*, McGraw-Hill World News, and *Electrical World*. His earlier activities included power-plant design and construction for the Hudson Ave. Station of Brooklyn Edison Company, Brooklyn, N. Y.

ASME 1948 Fall Meeting to Be Held Amid Magnificent Natural Beauty of American Northwest

ENGINEERS attending the 1948 Fall Meeting of The American Society of Mechanical Engineers to be held at Reed College, Portland, Ore., September 7–9, 1948, will not only be greeted by the hospitality traditional of the West, but will also have an opportunity to view a section of the United States whose natural magnificence is legend.

The technical sessions of the meeting will be held at Reed College, which is located on an 100-acre campus in the beautiful East Moreland residential district five miles from Portland city center. The central buildings of the campus are all in Tudor Gothic architecture. Behind the buildings of the campus, which of partly landscaped and partly in a state of natural beauty, is a deep ravine containing a small lake and the college swimming pool. This pool, the campus tennis courts, and the East Moreland Municipal Golf Course which adjoins the campus will be at the disposal of the delegates attending the meeting. Reed College has attained national recognition as a result of its experimental and highly individual approach to higher education and the professional achievement of its graduates.

During their stay in Portland, visiting members will journey to Bonneville Dam, forty-two miles from Portland, where they will view this huge hydroelectric plant which is connected to a network of other public and private power plants to create a pool of 3,800,000 kilowatts providing electric energy to this area at one of the lowest rates in the country. In addition to the hydroelectric plant, the ship lock and fish ladders are also of interest.

In addition, arrangements are being completed to permit the visitors to inspect the world's largest sawmill located at Longview, approximately 50 miles down the Columbia River. During the same visit, firms manufacturing wood-fiber products and paper will also be inspected.

One of the high lights of the meeting will be a tour to Timberline Lodge located on the slopes of Mt. Hood.

A full program of entertainment and special trips is also being arranged by the Woman's Auxiliary of the Oregon Section and all members attending the meeting are urged to bring their wives.

The papers planned for the technical sessions, the social events being arranged, the scenic beauty that abounds in the Portland area, and the opportunity to inspect some of the foremost plants in this rapidly growing industrial section, will make the Fall Meeting one that will be a memorable occasion to all those attending.

ASA Issues Revisions to Safety Codes

REVISION of two safety codes was recently announced by the American Standards Association. The first, "American Standard Safety Code for the Use, Care, and Protection of Abrasive Wheels, B7.1—1947," is a revision of the 1943 issue. Because of the increased use of small mounted wheels and points, two new tables have been added to the standard to cover critical speeds for wheels and points using $^3/_{32}$-in. spindles.

The second, "American Standard Safety Code for Power Presses and Foot and Hand Presses, B11–1947," is a revision of the 1937 issue and includes recommendations for safe installations of power presses as well as a wide variety of guards and feeding methods for all types of power, foot, and hand presses.

Aviation Division Plans Sept. Conference at Dayton, Ohio

THE Aviation Division of The American Society of Mechanical Engineers is co-operating with the ASME Dayton Section in holding what promises to be an interesting meeting on design for environment, to be held at Dayton, Ohio, Sept. 20 and 21, 1948.

The first day of the meeting will be devoted to technical sessions at which papers presented by civil and military authorities will cover certain aspects of the problem of designing for environment. For example, in discussing some of the problems connected with increasing the navigator's efficiency in arctic operations, the need for new equipment, or changes in existing equipment, as well as optimal layout will be considered. Problems connected with operation of jet engines operating under extreme ambient temperatures, whether hot or cold, are also to be discussed. A paper on special landing-gear problems encountered in landing in restricted places is also in process of preparation. There will be at least two technical sessions with three papers at each session. More details will be available later.

In the evening of Monday, there will be a general division dinner, at which the guest speaker will be a high-ranking officer who will discuss the over-all problem of designing for environment and give a preview of what the trip the next day will cover.

The second day will be devoted to an extensive tour of the research facilities at the Patterson-Wright Field Base conducted under the auspices of the military authorities at Wright Field. All members and guests of the Society who wish to go on this tour will have to be cleared through the proper channels before the day of the meeting, since the Wright Field trip arrangements are on restricted admission basis.

Inspection trips will be made to the various research laboratories where brief technical discussions will be held by army and civilian personnel.

AIP Announces New Physics Magazine

THE American Institute of Physics has announced publication of the first issue of a new monthly publication *Physics Today*. The new magazine is edited for readers in fields other than physics and aims to interpret the highly specialized work of research workers.

In addition to feature articles, the first 40-page issue contains a department, "Notes From Abroad," a "Washington Letter," and "Journal Notes" which contain reviews of books in the field of physics.

The American Institute of Physics, which publishes the new magazine, is made up of the technical societies in the field of physics and about ten thousand individual members who are physicists and others interested in physics. The Institute also publishes eight other technical journals.

Library Service Bureau Increases Rates

A study of operating costs has shown the need for increasing the rates on some of the services of the Engineering Societies Library, 29 West 39th Street, New York 18, N. Y., to make them self-sustaining. The Library is owned and operated by the Founder Societies which are: American Society of Civil Engineers; American Institute of Mining and Metallurgical Engineers; The American Society of Mechanical Engineers; and the American Institute of Electrical Engineers.

The Library Board has authorized the following rates effective June 1, 1948.

Literature searching (per hour)	$5.00
Translations (per hundred words)	
German, French, Italian, Spanish	$1.50
Russian, Dutch, Portuguese, Danish, Swedish	$2.00
Japanese, Chinese, Finnish, etc. Quotation on request	
Photostats (per print)	$0.40
Minimum charge per order	$1.00
Microfilm (per article from one volume)	$1.50
Book loans (per week for each volume)	$0.60

Members of the Founder Societies will continue to receive a discount of 20 per cent on searches and on translations, and a reduction of five cents on each photostat print if the work is ordered for their personal use.

Military Support for ERP Urged by W. L. Batt

PROMPT adoption by the United States of an effective bipartisan policy free of "day-to-day expedients" and backed by guarantees of adequate military support was urged by William L. Batt, past-president and Hon. Mem. ASME, at a joint dinner meeting of the ASME Milwaukee Section and the Engineering Society of Milwaukee held in Milwaukee, Wis., April 21, 1948.

Terming the need for decisive action "acute," Mr. Batt outlined a three-point program which, he said, would give "unmistakable evidence" of "our interest in a peaceful world." It called for:

1 A restatement of U. S. foreign policy "in the clearest and most certain terms."

2 A guarantee to the 16 co-operating nations that "we will protect the European Recovery Program from violent outside interference or irresponsible meddling."

3 Creation of a world government that will permit peace-loving people "to live under the assurance of peace—not the ever-present menace of war."

Both the President and the Secretary of State, he said, should tell the people "what our foreign policy is and what its objectives are."

"That statement, to be most effective, should be supported immediately by a pledge from the responsible heads of both major political parties—and perhaps even from the various presidental candidates—that the outcome of the November elections will not alter the foreign policy of the United States.

New York City Plans Air Exposition

AN International Air Exposition, marking the golden anniversary of the City of New York and the official opening of one of the world's largest airport centers, will be held at the New York International (Idlewild) Airport, July 31–Aug. 8, 1948.

In the heart of the exposition area will be a "World of Flight" section which will hold exhibits of aircraft, production techniques, research projects, aircraft service and maintenance equipment, and airport facilities. A feature of the exposition will be mass reviews and precision maneuvers by the Armed Forces.

The ASME is co-operating with the Society of Automotive Engineers in planning an International Air Transport Luncheon to be held on the third day of the exposition, Aug. 2, 1948. Frederick K. Teichman, college of engineering, New York University, is the ASME representative on the luncheon-planning committee. Sir William Hildred, director, International Air Transport Association, will be the principal luncheon speaker. Admiral Emory S. Land will be toastmaster.

Meetings of Other Societies

June 6–11
Society of Automotive Engineers, Inc., semiannual meeting, French Lick Springs Hotel, French Lick, Ind.

June 14–18
American Society for Engineering Education, annual convention, Austin, Texas.

June 21–25
American Institute of Electrical Engineers, summer general meeting, Palace of Fine Arts, Mexico City, Mex.

June 21–27
American Society for Testing Materials, annual meeting, Detroit, Mich.

July 20–22
American Society of Civil Engineers, annual convention, Hotel Olympic, Seattle, Wash.

August 24–27
American Institute of Electrical Engineers, Pacific general meeting, Spokane, Wash.

August 30
American Chemical Society, 114th national meeting, Washington, D. C.

(*For ASME Meetings see page 566*)

PRINCIPALS AT THE JOINT MEETING OF THE CINCINNATI SECTION AND THE UNIVERSITY OF CINCINNATI STUDENT BRANCH

(*Left to right:* J. W. Bunting, A. Stolley, R. L. Smith, H. S. Malaney, F. F. Borries, J. F. Bertsch, G. Neubauer, and F. H. Braun.)

Section Activities

Cincinnati Section Meets With Local Student Branch

On Thursday, March 4, 1948, the student branch of ASME at the University of Cincinnati held a joint meeting with the Cincinnati Section at the Engineering Society of Cincinnati. The program was handled by Alex Stolley, student chairman, and John Martin, program chairman, in conjunction with H. B. Welge of the Cincinnati Section, and was preceded by a dinner at which the senior members, students, and professors intermingled.

The program consisted of the presentation of three papers by student members. The first paper was co-authored by John Klover and Joseph Bertsch and was entitled, "Compression Characteristics of Some Common Fluids." Klover presented the paper in which the authors showed a new and simple device for determining the compressibility of fluids.

The other papers were "Flame Spraying of Nonmetallic Materials," by Gordon Zeidman and Louis Patalita, and "Development of a New Tool Dynamometer," by Alex Stolley. After the papers were given, a secret vote was held for the best paper and the prizes for junior memberships for the coming year were won by John Klover and Joseph Bertsch.

Following the presentation of prizes, students and senior members enjoyed refreshments.

April 29, Engineering Societies Building, Cincinnati, Ohio. Speaker: E. G. Bailey, president ASME. Subject: The Engineer's Opportunities. Attendance: 237.

This meeting, the most successful of the season, was attended by student members from the Universities of Cincinnati, Dayton, and Ohio State. Among the honored guests was T. E. Purcell, vice-president ASME Region V. Following President Bailey's talk, members and students joined in an informal discussion of the engineering profession with emphasis of the problems facing the young engineer.

Akron-Canton

April 16, Mayflower Hotel, Akron, Ohio. Symposium on the Design and Manufacture of Rubber Tires. Speakers: R. D. Evans, manager, tire-design research; W. H. Elliott, manager, field-engineering department; L. W. Fox, manager of field engineering, all of Firestone Tire & Rubber Company. Attendance: 71.

Boston

April 13, Northeastern University. Joint forum with AIEE. Subject: The Engineer in Management. Speakers: W. F. Ryan, Fellow ASME, engineering manager, Stone and Webster Engineering Corporation, Boston, Mass., F. D. Campbell, president, North East Gas and Electric Association, and C. A. Powel, assistant to vice-president, Westinghouse Electric Corporation. Educational institutions and their preparation of engineers for management was the subject of a talk by Dean W. T. Alexander, Mem. ASME, of Northeastern University. Attendance: 300.

April 21, Boston City Club, Boston, Mass. Speaker: C. E. Davies, secretary, ASME. Subject: The ASME and the Younger Members. Attendance: 90.

April 27, Massachusetts Institute of Technology, Cambridge, Mass. Speaker: Dr. Francis Martinuzzo. Subject: Continental Gas-Turbine Development. Attendance: 140.

Cleveland

April 8, Case Institute of Technology, Cleveland, Ohio. Speaker: Elmer L. Lindseth, Mem. ASME, president, Cleveland Electric Illuminating Company, Cleveland, Ohio. Subject: The Biggest Job Is Just Beginning. This was the annual meeting with the student branch of the Institute.

Central Iowa

April 13, Younker's Tearoom, Des Moines, Iowa. Speaker: H. Bornstein, director of research, Deere and Company. Subject: Engineering Materials and Their Application. Attendance: 100.

Detroit

April 13, Rackham Building, Detroit, Mich. Speaker: P. W. Swain, Mem. ASME, editor, *Power*, New York, N. Y. Subject: The Future of Atomic Power. Attendance: 70.

Florida

April 21, Seminole Hotel, Jacksonville, Fla. Speaker: W. J. Fritton, 2nd, Jun. ASME, works engineer, Van der Horst Corporation, Olean, N. Y.

Fort Wayne

Feb. 5, Chamber of Commerce, Ft. Wayne, Ind. Speaker: Richard Lowe, senior mechanical-engineering student, Indiana Technical College. Subject: Panel Heating and Heat-Pump Applications. Attendance: 72.

March 4, Chamber of Commerce, Ft.

MEMBERS OF THE ASME MID-CONTINENT SECTION INSPECTING A TRUCK USED IN SEISMOGRAPH OPERATIONS DURING A VISIT TO THE CARTER OIL COMPANY, TULSA, OKLA.

Wayne, Ind. Speaker: John C. Straub, chief research engineer, American Wheelabrator and Equipment Corporation. Subject: Shot Peening. Attendance: 22.

April 1, Chamber of Commerce, Fort Wayne, Ind. Speaker: Everett C. Buck, Mem. ASME, consulting engineer. Subject: Buck System of Floor Panel Heating and Cooling. Attendance: 35.

Metropolitan

March 11, Engineers' Forum. Engineering Societies Building, New York, N. Y. Speaker: John de S. Coutinho, Grumman Aircraft Engineering Corporation. Subject: World Engineering Conference.

Mid-Continent

Feb. 26. Tour of the research laboratory and shop of the Carter Oil Company, under the direction of Dr. R. N. Meinert, assistant director of research of the Laboratory. Attendance: 55.

March 12, 13. Joint meeting with student branches, Mayo Hotel, Tulsa, Okla. Speaker: J. T. Rettaliata, Mem. ASME, director of the School of Mechanical Engineering, Illinois Institute of Technology, Chicago, Ill. Subject: Jet Propulsion.

In the annual competition for the best papers presented by Mid-Continent student branches, Charles J. Mauck, University of Oklahoma, was awarded first prize of $50 for his paper "Dual-Fuel Diesel—Its Performance and Application." Second prize to George L. Lange, Oklahoma A&M College, for "Mechanical Applications of High-Frequency Heating." Third prize to Leon O. Briggs, Oklahoma A&M, for "The Alfalfa Dehydrating Industry." Fourth prize to Phillip M. Rubins, University of Oklahoma, for "Mechanical Engineers in the Design of Prefabricated Houses."

Oregon

April 9, Chamber of Commerce Building, Portland, Ore. Joint meeting with the Oregon State College branch. Papers were presented by students for prizes totaling $55. First prize was won by George Frank for his paper "What's New in Gas Turbines?" Second award to G. O. Kerrebrock for his paper "The New Look in Small Tractors;" third to W. G. Wooley for "Conversion of a P-T Boat to Peacetime Uses;" fourth and fifth to E. T. Case and J. W. Whitsett, for "Development of Smoke Jumping Aircraft Loadings;" honorable mention to Roscoe Clarke for "Use of Diesel Engines in Modern Transportation;" and B. E. Deckman for "High-Pressure Centrifugal Pumps." Attendance: 42.

St. Joseph Valley

April 7, annual contest for students at the University of Notre Dame. First prize to Norman Lalone for his paper "Domestic Heating Systems." Second prize to Robert Percival. Third prize tied between James Laskoske and Robert Schafer. Fourth prize, John Fager.

April 20, Purdue University. Joint meeting with Central Indiana and Fort Wayne Sections, with student branches of Purdue and Rose Polytechnic Institute. Speaker: E. G. Bailey, president ASME. Attendance: 36.

May 20, Engineer's Club, South Bend, Ind. Annual business meeting and election of officers.

S. P. TIMOSHENKO (*left*) RECEIVES CERTIFICATE OF AWARD FROM W. H. MCBRYDE AT JOINT MEETING OF ASME SAN FRANCISCO SECTION AND THE AMERICAN SOCIETY FOR TESTING MATERIALS

San Francisco

March 25, The Engineers Club, San Francisco, Calif. Speaker: T. A. Boyd, president ASTM, and research consultant for General Motors Corporation. Subject: Research on Materials and Mechanisms. An ASME award for achievement was presented to Dr. S. P. Timoshenko, Fellow ASME, professor of applied and theoretical mechanics, Stanford University, Calif. Attendance: 130.

April 8, El Jardin Restaurant, San Francisco, Calif. Meeting of the machine design division. Speaker: George Nordenholt, chairman of the National Machine Design Division, and chief editor, *Production Engineering*. Subject: Responsibilities of Machine Design in Industry. Attendance: 24.

Schenectady

April 27, Union College, Schenectady, N. Y. Speakers: J. C. Fisher, J. G. Leschen, and J. D. Lubahn, all from the research laboratory of General Electric Company, Schenectady, N. Y. Subject: Colloquium on Mechanical Behavior of Metals. Attendance: 15.

Western Washington

April 8, Everett, Wash. Following dinner at Smorgasbord, a field trip was made through the Weyerhaeuser Pulp Mill. Attendance: 95.

Youngstown

April 13. Joint meeting with local sections of AIEE and American Welding Society. Westinghouse Auditorium, Sharon, Pa. Speaker: Hal Toner, electronic engineer, Westinghouse Electric Corporation. Subject: Electronic Heat. Attendance: 180.

Keep Your ASME Records Up to Date

HEADQUARTERS depends on its master membership file for answers to hundreds of inquiries daily pertaining to its members. All other Society records and files are kept up to date through changes processed through it. The listings in future ASME Membership Lists will be taken directly from the master file. It is important to you that it lists your latest mailing address and your current business connection.

The mailing form on this page is published for your convenience. You are urged to use it in reporting recent changes.

Your mailing address is important to Headquarters. Please check whether you want your mail sent to home or office address.

Action at this time is important because a new Membership list is planned for fall publication. Accuracy of your personal data depends upon you.

ASME Master-File Information

Please Print — **Check Mailing Address**

Name ..... (Last / First / Middle)

Home Address ..... ☐ (Street / City / Zone / State)

Name of Employer .....

Address of Employer ..... ☐ (Street / City / Zone / State)

Product or Service .....

Position or Title .....

Notify Headquarters Promptly of Changes

Engineering Societies Personnel Service, Inc.

These items are from information furnished by the Engineering Societies Personnel Service, Inc., which is under the joint management of the national societies of Civil, Electrical, Mechanical, and Mining and Metallurgical Engineers. This Service is available to members and is operated on a co-operative nonprofit basis. In applying for positions advertised by the Service, the applicant agrees, if actually placed in a position through the Service as a result of an advertisement, to pay a placement fee in accordance with the rates as listed by the Service. These rates have been established in order to maintain an efficient nonprofit personnel service and are available upon request. This also applies to registrants whose notices are placed in these columns. Apply by letter, addressed to the key number indicated, and mail to the New York office. When making application for a position include six cents in stamps for forwarding application to the employer and for returning when necessary. A weekly bulletin of engineering positions open is available to members of the co-operating societies at a subscription of $3.50 per quarter or $12 per annum, payable in advance.

New York	Chicago	Detroit	San Francisco
8 West 40th St.	211 West Wacker Drive	109 Farnsworth Ave.	57 Post Street

MEN AVAILABLE[1]

INDUSTRIAL ENGINEER, degree. Twenty-five years' experience in methods, layout, materials handling, incentives, time study, budgets, training, job evaluation, cost reduction, investigations, reports, and supervision. Skilled with labor. Capable organize and administer programs in industrial-engineering, cost reduction, training, wage and salary administration. Me-291.

MECHANICAL ENGINEER, 30, Chinese, BSME. Will get MME in June, 1948. Eight years' experience in mechanical and chemical industries. Desires position with American concern in China after training here as technical representative. Me-297.

ENGINEER OR TEACHER. Ten years' experience in power-plant operation and plant maintenance, and 25 years in teaching heat, hydraulics, and combustion engines. Me-298.

MECHANICAL ENGINEER, 40, graduate, MIT, 16 years' experience plant engineer, master mechanic, plant superintendent. Time-study, methods, building-design, construction, gray-iron and brass-foundry, aluminum-foundry, tool and die-making, machine-shop, power-plant, structural-steel, reinforced-concrete, and mining experience. Location desired, United States or foreign. Me-299.

MECHANICAL ENGINEER, BSME, 24, with three and a half years' marine engineer, one year testing power-plant equipment. Has chief engineer's marine license. Desires position in power-plant engineering, consulting firm, or similar. New York, N. Y. Me-300.

MECHANICAL ENGINEER, 25, single. Two and a half years oil company general construction, office, and field; one year aircraft-engine gear development. Member three honor societies. Prefers opportunity to security. Desires petroleum mechanical-engineering work. Available, July 1, 1948. Location preferred, Southern California. Me-301-484-D-9.

PRODUCTION MANAGER OR ASSISTANT. Purdue, mechanical-chemical, 40, experienced supervision, development, quality and waste control, design, construction, some operation, principally paper manufacturing. Can effect production economies, good labor relations. Me-302.

MECHANICAL ENGINEER, registered PE plant utilities, combustion, heating, process, specialize in analysis, application, distribution, design, control, efficiency. Desires connection with large or multiplant industry on staff level. Me-303.

CHIEF ENGINEER, MANAGER, OR PLANT ENGINEER, 51, registered, 30 years' experience in active charge of development, design, and construction of industrial processing, hydraulic and pneumatic equipment, machine tools, power plants, and powerhouses. Me-304.

[1] All men listed hold some form of ASME membership.

POSITIONS AVAILABLE

SALES ENGINEER, 28–38, with mechanical-, civil-, electrical-, chemical- or administrative-engineering degree, and at least five years' selling experience, to sell industrial high-pressure liquid pumps. Will contact existing dealers and procure new dealers; will contact national manufacturers' accounts and procure new accounts. $3000–$3600, including commissions and travel expenses. Headquarters, Michigan. Y-669-D.

TEACHING PERSONNEL. (*a*) Associate professors, capable of organizing and teaching junior and senior machine design and allied courses. Should have considerable professional attainments, advanced academic work, and actual engineering experience. $4100–$5000. (*b*) Assistant professors, capable of teaching basic engineering subjects. Chief interest should be in the field of machine design. Advanced academic work required. Engineering experience desired. About $3700. (*c*) Instructor in mechanical engineering, recent graduate with master's degree. About $3000. Upstate New York. Y-676.

INSTRUCTORS in mechanical engineering, to teach applied mechanics and elementary mechanical-engineering courses, such as kinematics, materials of engineering, and mechanical laboratory. Position starts in the fall. Maine. Y-679.

DEVELOPMENT ENGINEER, mechanical graduate, with farm-equipment experience, to take charge of development of cultivators. Some traveling involved. $5000–$6000. New York metropolitan area. Y-707.

ENGINEERS. (*a*) Designer, 30–40, mechanical graduate, with at least three years' motor-design experience, to design bearings, shaft, and gears. $4000–$5000. (*b*) Product engineer, 30–35, mechanical graduate, with process-equipment experience, to be responsible for production and application of cleaning equipment. $4200. Northern New Jersey. Y-709.

SUPERINTENDENT, 35–45, preferably mechanical graduate, with at least five years' experience as superintendent or assistant superintendent in boiler or process-plant equipment manufacturing, to supervise fabrication of plate work, heat exchangers, and tube equipment. $6000–$8000. Western New York. Y-714.

RECENT GRADUATE MECHANICAL ENGINEERS to start at the bottom in fertilizer business. After training and working at different plants through the States they will be assigned to permanent position. Reasonable starting salary with very good opportunities. Headquarters, New York, N. Y., with plants located throughout the United States, large one in Detroit, St. Louis, Buffalo, and others in Canada. Y-729.

MECHANICAL ENGINEER, graduate, to act as assistant to the chief engineer and superintendent of maintenance of a hospital. Should have adequate training and experience eventually to take over duties of chief engineer. $3600–$4200. Pennylsvania. Y-737.

INSTRUCTOR, mechanical or industrial engineer, to teach the following subjects: process engineering; manufacturing and tool costs; manufacturing analysis; production procedures; and tool design. Position starts September 7, 1948. $2500–$3000. Connecticut. Y-763.

MECHANICAL ENGINEER with New York State license, to prepare and conduct engineering examinations, both written and oral, and to do usual other personnel recruitment. $3890. New York, N. Y. Y-791.

MECHANICAL ENGINEER, 30–35, with bottling and beverage-plant process and production experience, for staff position with brewery. $4000–$5000. Northern New Jersey. Y-792.

ENGINEERS. (*a*) Assistant to plant superintendent in charge of maintenance, mechanical degree, for large manufacturer in food industry. Should have at least 5 to 10 years' experience in automatic equipment, particularly electromechanical automatic devices. $5600–$6000. New York, N. Y. (*b*) Recent graduate, mechanical. Will be trained in various plants throughout the United States. $3300. Y-803.

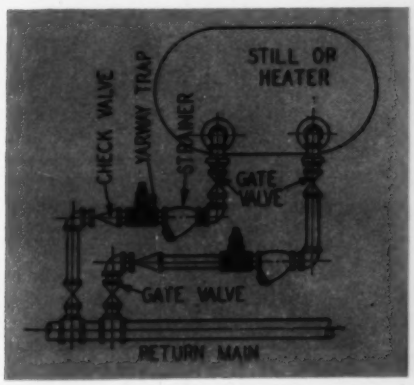
SALES ENGINEER, mechanical graduate, with plastics-sales or production experience, to sell cold-molded plastic powders. Some traveling. $3000, plus commission. Northern New Jersey. Y-818.

DESIGN-DRAFTSMAN, 30–35, mechanical degree, with heavy-machine design experience, to design and lay out special machinery. $4000–$5000. Northern New Jersey. Y-820.

ENGINEERS. (*a*) Mechanical engineer, 40–

(*ASME News Continued on page 574*)

TYPICAL APPLICATION—Yarway Impulse Steam Traps with Yarway Fine-Screen Strainers draining liquid heater.



600,000 Salesmen

Users tell us the most convincing salesman of Yarway Impulse Steam Traps is the trap itself. In plant after plant, now 100% Yarway-equipped, the maintenance engineer started with one Yarway trap. In less than ten years over half a million Yarways have been bought by utilities, institutions, industrial plants and ship-operating companies. Here are the reasons:

ONLY ONE MOVING PART. No levers, buckets, weights, bellows or floats. The only moving part is a simple valve. Result—Easy maintenance and small inventory of parts.

SMALL SIZE . . . LIGHTWEIGHT. Hardly larger than a pipe union, Yarways require no support other than the pipe line. Installations are simpler, neater, more practical.

GOOD FOR ALL PRESSURES. Yarways are good for all pressures within a broad range without change of valve or seat. Factory set.

EFFICIENT OPERATION. Yarways discharge condensate rapidly. Users from coast-to-coast report they get equipment hotter, sooner, and maintain peak efficiency. Small amounts of condensate discharge continuously through control orifice in valve; at medium loads, main valve opens and closes at short intervals; under heavy loads, valve opens wide.

LOW COST. Often it costs no more for new Yarways than to repair old type traps. See your nearest Mill Supply Dealer or write for Bulletin T-1739.

YARNALL-WARING COMPANY • 108 Mermaid Ave., Philadelphia 18, Pa.

YARWAY IMPULSE STEAM TRAP

45, preferably with a professional engineering license, to take responsible charge for a consultant on heating, ventilating, air-conditioning, plumbing, and possibly electrical work for industrial buildings. $6500. (*b*) Mechanical draftsman and designer for air-conditioning work. Must be able to make own calculations, although will operate under supervision. (*c*) Electrical engineer with some experience in lighting for commercial and industrial buildings. Salaries open. New York, N. Y. Y-825.

ASSISTANT CHIEF PLANT ENGINEER, 35–45, mechanical degree, with knowledge of maintenance, construction, plant engineering, utilities, and refrigeration. Should have broad business experience, for company refining corn products, brewing and processing yeast. $12,000, plus bonus. Middle West. Y-827.

EXECUTIVE ASSISTANT TO VICE-PRESIDENT, 38–42, mechanical or chemical graduate, with extensive petroleum- and process-equipment experience including at least five years as chief engineer, to take general charge of plant construction, process equipment, purchase of new facilities, and commercial research; with some traveling. $15,000–$20,000. Headquarters, New York, N. Y. Y-836.

MECHANICAL ENGINEER AND DRAFTSMAN familiar with sugar-mill process piping, for equipment layout. $7800. Some traveling to plant. New York, N. Y. Y-850.

EXPORT ENGINEER, mechanical graduate with several years' machinery experience, covering quotations, specifications, freight forwarding, and credits, $3600, plus commission. New York, N. Y. Y-855.

MECHANICAL ENGINEER, 35–40, who has had a production background. Must be able to design and have ability to go into plant and participate in the production of the items. Salary open, depending upon experience. New York State. Y-856.

PLANT MANAGER, mechanical graduate, 35–45, who will be in complete charge of operation, maintenance, cost, and manufacturing techniques for process manufacturing plant employing 300 to 500 people. $10,000. Northern New Jersey. Y-857.

ENGINEER, 26–40, mechanical graduate. Should have four years' general experience, preferably textile experience. Duties will be general engineering work in connection with the mechanical development phases of product research and development. This work covers the development, design, and follow-through on the erection and testing of equipment for new products and new processes. $4200. Connecticut. Y-862.

MECHANICAL DESIGNER, preferably with experience in powerhouse design. The work consists of the design and layout of mechanical and electrical services and equipment for a one-thousand-bed hospital. Also included in the project is the design of a small powerhouse. National engineers will assist in the preparation of plans and working out details of services. Temporary, one year. $7102, plus living allowance and housing. Central America. Y-867.

MECHANICAL SUPERINTENDENT to take complete charge of the mechanical and power departments in a large meat-packing plant. Should have considerable experience both in power-plant and refrigerating engineering, also in maintenance work. Maryland. Y-869.

MECHANICAL OR ELECTRICAL ENGINEER, with design, development, and cost-estimating experience in appliance or apparatus field, to be responsible for estimates, design, development, subcontracting, and assembling of new products in household-appliance, governmental, and industrial fields. $4800–$5400. New York metropolitan area. Y-871.

SENIOR MECHANICAL ENGINEER, 28–35, BSME with about four years' experience in developing accessories or redesigns of machines to improve quality or cut processing costs, to develop new and improved processes for handling a variety of mechanical operations. Design and develop new machines or machine accessories. $3600–$5400. Massachusetts. Y-891.

TEACHING PERSONNEL. (*a*) Assistant professor to teach elementary drafting, machine drawing, and descriptive geometry. $3500 for three-term year. (*b*) Instructors, to teach elementary mechanical engineering, mechanisms, kinematics, machine design, thermodynamics, power-plant design, time and motion study, and heating, ventilating, and air conditioning. Subjects will be assigned according to experience of the applicant. Starting salary, approximately $3000 for three-term year. Michigan. R-4784.

EXPORT SALES ENGINEER, engineering graduate, 32–40, with working knowledge of one or more modern foreign languages. Will work on preparation of proposals to customers or through distributors, also sales correspondence with them, and attend to customers and distributors visiting United States. Preferably experienced in sale of motors and hydraulic pumps. Other products of company are welders, oil-well casings, and piping, pressure vessels, heat exchangers, centrifugal pumps and blowers, petroleum meters and pumps, and liquid level gages. Position permanent. $500–$550 a month. Wisconsin. R-4886-C.

GRADUATE MECHANICAL ENGINEER, preferably with some transportation and packaging experience, for national organization with headquarters in Chicago. Position requires traveling throughout United States and Canada. Knowledge of and previous experience with railroad transportation desirable, but not necessary. Work will involve preparation of specifications, reports, participation in tests on shipping containers for all commodities, and methods of loading and bracing commodities in freight cars as well as designing interior packing, bracing, and cushioning of various commodities. Starting salary, $400 a month and all expenses when traveling. R-4907-C.

MECHANICAL DESIGN DRAFTSMAN, four to six years' experience in mechanical design, preferably on linkages of medium weight. Knowledge of bearings, gears, and metallurgy required. Excellent opportunity with manufacturer of high-voltage switch gears. S-643.

Candidates for Membership and Transfer in the ASME

THE application of each of the candidates listed below is to be voted on after June 25, 1948, provided no objection thereto is made before that date, and provided satisfactory replies have been received from the required number of references. Any member who has either comments or objections should write to the secretary of The American Society of Mechanical Engineers immediately.

KEY TO ABBREVIATIONS

Re=Re-election; Rt=Reinstatement; Rt & T=Reinstatement and Transfer to Member.

NEW APPLICATIONS

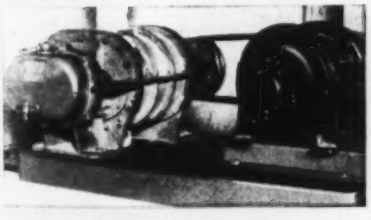
For Members, Associate, or Junior

ALVEY, COURTNEY D., Baltimore, Md.
ANDERSON, AXEL F., Detroit, Mich.
ANDRUSS, THAXTER H., Oakland, Calif. (Rt & T)
BARRON, LESLIE A., Chicago, Ill.
BARTH, EUGENE W., Pittsburgh, Pa.
BIXBY, ARTHUR M., East Haven, Conn.
BOWDEN, THOMAS J., Darby, Pa.
BOYD, JOHN, Pittsburgh, Pa.
BRANDT, MORRIS, JR., New York, N. Y.
BRENSILBER, JOSEPH, New York, N. Y.
BRINKMAN, HAROLD L., Flushing, N. Y.
BURBRIDGE, RUSSELL W., Los Angeles, Calif.
BURNS, JAMES F., St. Albans, N. Y.
CAPONI, ELSO RENALDO, Washington, D. C.
CARNICER, LUIS, Havana, Cuba
CASLER, WALTER E., Bronx, N. Y.
CASTELFRANCO, JAMES, South Gate, Calif.
CHADWICK, JUNIUS W., Spartanburg, S. C.
CHRISTENSEN, CARLO M., Freeport, Ill.
CHIERI, PERICLE A., Newark, N. J.
CLIMENT, FRANCIS J., Los Angeles, Calif.
CONNOLLY, WILLIAM W., St. Albans, N. Y.
CROWLEY, JAMES A., Chicago, Ill.
CRYMBLE, ALFRED CARTER, Kingsport, Tenn.
CURRY, ROBERT F., Detroit, Mich.
DADD, MELVIN W., Cincinnati, Ohio
DAHLSTRUM, ALFRED, Huntington Park, Calif.
DESBARATS, GEORGE H., St. Johns', Newfoundland
DEVALL, LUCIEN, Gulfport, Miss.
DITIRRO, DOMENIC A., Euclid, Ohio
DUKE, PAUL A., Atlanta, Ga.
EL ALAILY, MOHAMED M., Manchester, England
EVANS, HARRY M., Tulsa, Okla.
FARDELLA, JESS V., Coraopolis, Pa.
FENSTERMACHER, HARRY DAVID, Reading, Pa.
FIELDS, RAYMOND H., Depew, N. Y.
FINN, LEONARD C., St. Louis, Mo.
FISH, RICHARD KENNETH, Seattle, Wash.
FOSTER, WM. C., Washington, D. C.
FOX, MILTON RUSSELL, Detroit, Mich.
GENSAMER, MAXWELL, Pittsburgh, Pa.
GLIMSTAD, DOUGLAS C., Sacramento, Calif.

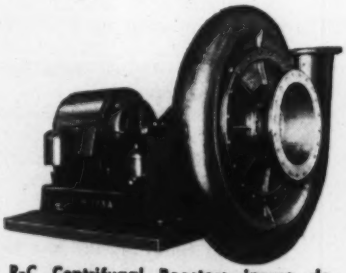
(*ASME News Continued on page 576*)

The first Rotary Positive Blower built by anyone was produced in the "Roots" plant in 1854—six years before the first pony express. We're not good because we're old, we're old because we're good!

GRANDMA LIVED 90 YEARS TOO SOON



R-C Rotary Positive Blower built into modern gas-oven equipment to maintain constant, correct gas flow for even baking temperatures.



R-C Centrifugal Boosters insure deliveries of gas in sufficient quantities, at the right pressures for home, commercial and industrial users.

When she made those mouth-watering cookies, Grandma didn't have perfect baking temperatures, obtained from an even flow of gas. Even though "Roots" equipment was available almost 100 years ago, neither home nor commercial bakers had learned how to apply it to making cookies.

Now, it's different. Roots-Connersville Rotary Positive or Centrifugal Gas Pumps and Boosters help regulate gas and air supplies for every industry, where reliable performance is essential for profitable operations.

With our *dual-ability* to supply either *Centrifugal* or *Rotary Positive* equipment, we can match capacities, pressures and other factors to the job to be done . . . with complete impartiality. For any work of handling air or gas—ask R-C *dual-ability* to do the job faster, better, cheaper.

ROOTS-CONNERSVILLE BLOWER CORPORATION
806 Michigan Avenue, Connersville, Indiana

ROOTS-CONNERSVILLE
ROTARY CENTRIFUGAL
BLOWER BUILDERS R-C SINCE 1854
BLOWERS · EXHAUSTERS · BOOSTERS · LIQUID AND VACUUM PUMPS · METERS · INERT GAS GENERATORS

★ ★ ONE OF THE DRESSER INDUSTRIES ★ ★